How to make

PATTERNS *and* MODELS *with* GYPSUM CEMENT

Industrial Division
UNITED STATES GYPSUM COMPANY

A corner of a large pattern shop devoted exclusively to making extremely accurate patterns of gypsum cement. The men in the foreground are doing handwork on built-up patterns. The widespread practice of subcontracting parts, and of producing the same article in various plants, frequently makes it necessary that duplicate Master patterns be furnished, and gypsum cement is the only material suited to this purpose since it does not change form or dimension under varying temperature and humidity conditions.

Why Gypsum Cement?

Today's demands for speed, accuracy and extensive contouring of models and patterns are causing pattern shops all over the country to seek improved materials and methods to fulfill these needs.

Experience has proved that complex contours and intersections can be accurately and quickly developed with gypsum cements. Furthermore, patterns or models made from U·S·G* gypsum cements retain their accuracy of dimension under varying temperature and humidity conditions.

Briefly summarized, the advantages and benefits of patterns and models made of gypsum cements are:

1. **Saving in pattern making time.**
2. **Accuracy and stability of dimensions.**
3. **Adaptability to complex contours and intersections.**
4. **Ease of producing sectional dies from full scale mock-ups.**
5. **Flexibility of design in making complicated mock-ups and check fixtures.**

U·S·G research engineers have developed a line of special gypsum cements to provide the foundry and metal forming industry with a range of materials that will meet the various special requirements of different patterns.

This manual has been prepared to supply *basic* information for using these cements. If the methods outlined here are followed, the result will be a precise pattern or model.

*Trademark Reg. U.S. Pat. Off.

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What Are Gypsum Cements?

Gypsum cements are made from a natural mineral—gypsum rock either white or grey. It is finely ground and properly calcined to obtain a uniform product. By controlling calcining and further processing, predetermined characteristics are produced in the cement.

U·S·G thru constant research and improvement in manufacturing technique has developed *basically* different products to meet the requirements and wide range of special properties demanded by industry today.

Unique Characteristics of Gypsum Cements

Gypsum cements, when mixed with water, form plastic masses which can be molded, shaped or cast.

This plastic mass begins first to thicken, then harden, then set. The thickening or "creaming" stage varies in length of time with different types of cement. To the pattern maker this "thickening" stage is the most useful, interesting and phenomenal one, and it is accurately described as the "period of plasticity."

During this period, it can be formed by hand, screeded (or formed) with a template; and reinforced with hemp, sisal, wire mesh, expanded metal, burlap or muslin.

The various stages of this "period of plasticity" should be observed very closely by the pattern maker because specific results can be achieved at *certain stages* and *certain stages only*. The experienced pattern maker waits until the proper plastic stage is reached before working the gypsum cement.

FIGURE 1

To be successful in making patterns with gypsum cement, the craftsman must familiarize himself with all phases of the "creaming" or thickening stages of the cement, known as its "Period of Plasticity." Immediately after mixing at normal consistency, the cement is fluid and free-flowing.

Utilizing the "Period of Plasticity"

This valuable period is the one which is most frequently neglected, to the user's disadvantage. It is during this plastic period that the cement should be used to build up patterns and to screed them to shape with templates, because at this time it can be modeled readily, since it has a "controlled" flow. This eliminates the need for molds or "boxing in" which would be necessary if using it in its "free-flowing" state.

A little study and experience will quickly show how the progressive plasticity of the cement can be utilized. Different areas of the pattern will require different stages of plasticity, because as this plastic period progresses, the cement gains strength or body, and can be built up to the contours required.

The length and character of this period of plasticity varies with different types of gypsum cement, so the type should be selected that will meet the requirements of each job. A list of these U·S·G cements and a brief summary of their distinctive characteristics will be found on page 45 in this manual.

FIGURE 2

A few minutes later, the mix begins to thicken and have body so that it can be built up. Note that the "period of plasticity" is progressing. The mix must be handled quite delicately at this stage as slight jarring will cause it to slump and lose shape.

FIGURE 3

Gradually the "period of plasticity" progresses and the mix becomes thicker. Each spoonful can now be distinguished. Compare the edges of the last spoonful with the indistinct outlines of the first.

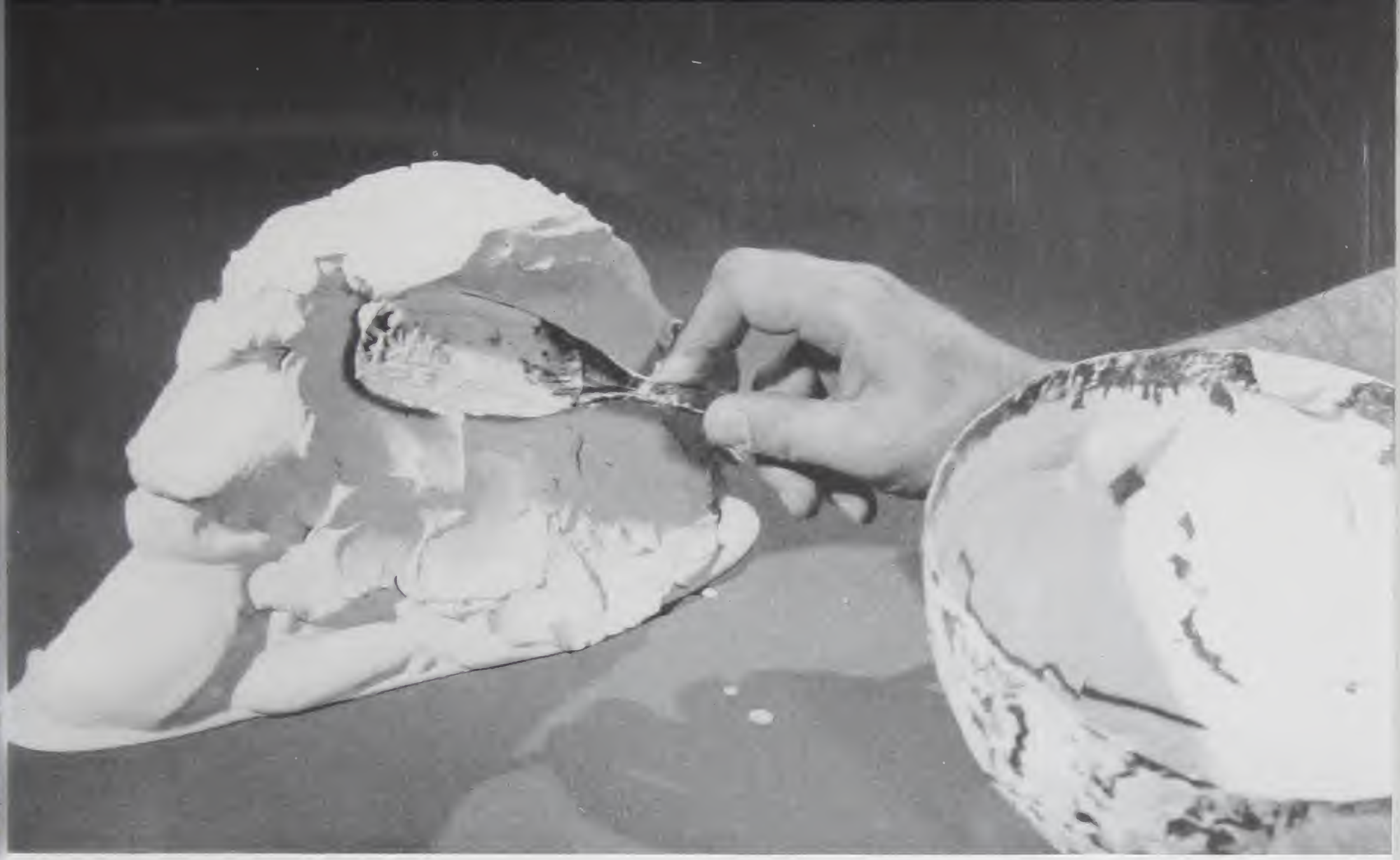


FIGURE 4

As the period of plasticity progresses further the spatula may be substituted for the spoon. The spatula is especially well suited to forming the material at this stage. The gypsum cement has gained strength but can still be formed or shaped at will.

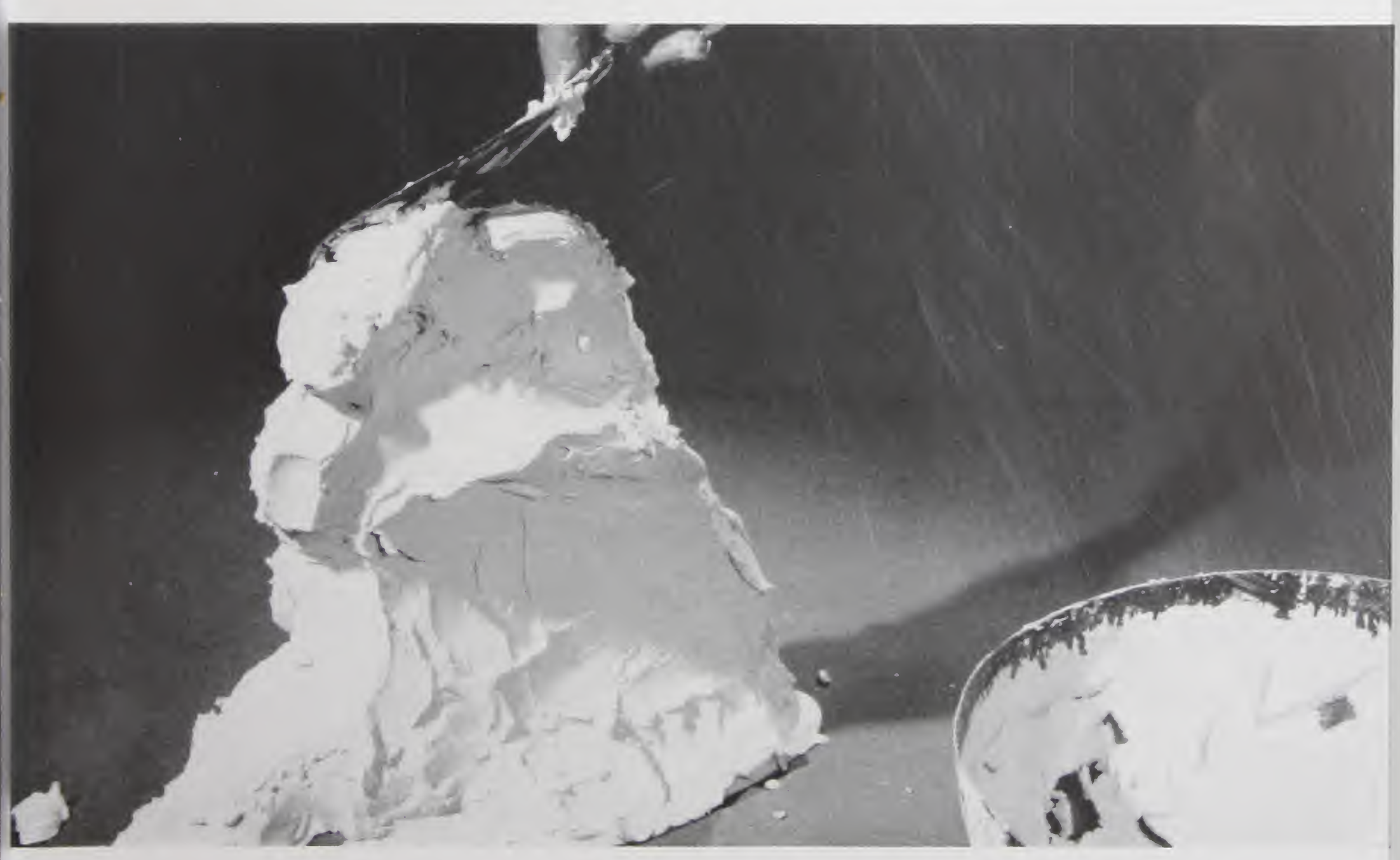
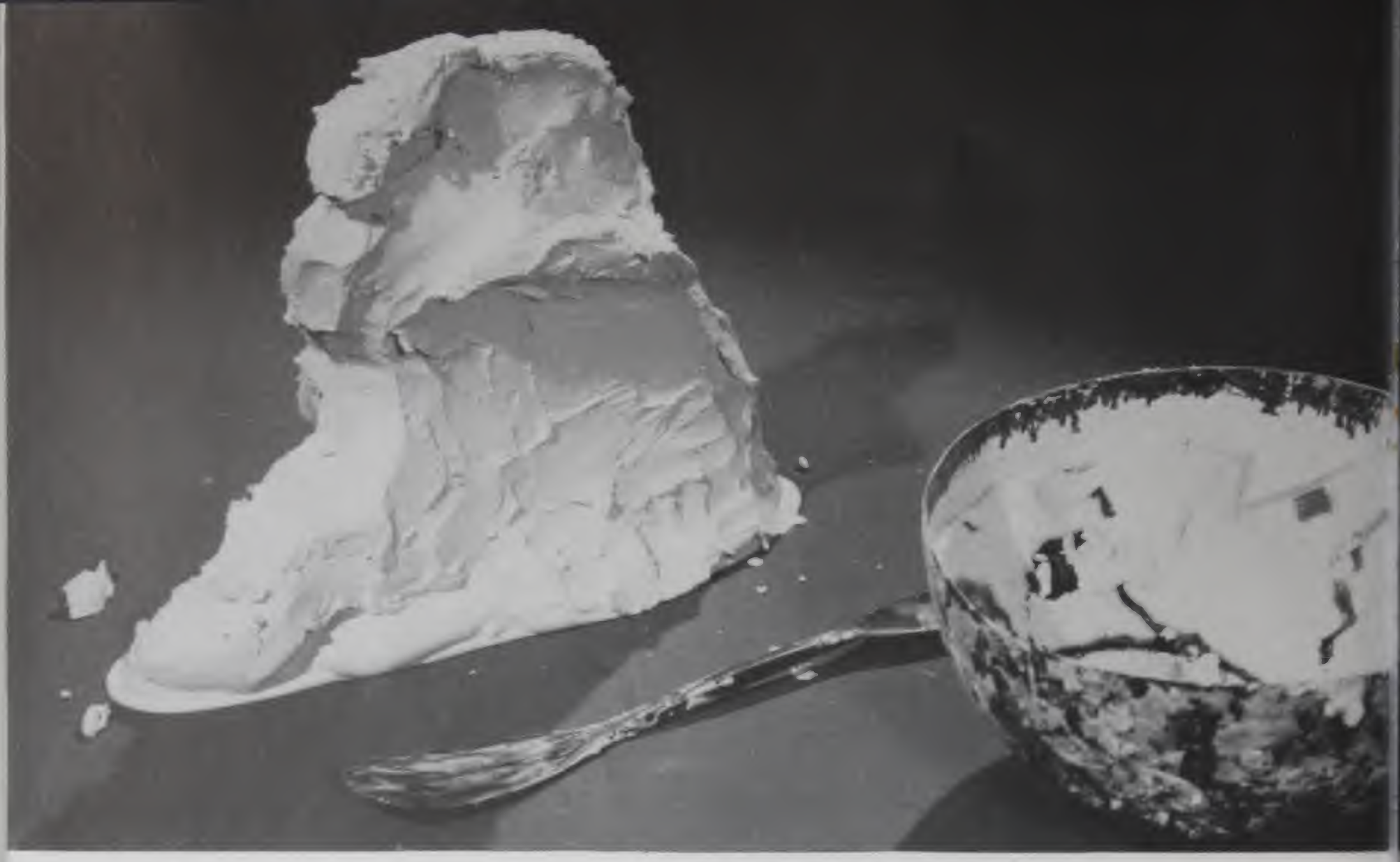


FIGURE 5

Now the "period of plasticity" is ending. The mix is becoming harder and less plastic. Surfaces are inclined to crumble and bond becomes difficult. The gypsum cement is now going into its initial set.

FIGURE 6



The period of plasticity has ended and the mix has set to a hard mass which can now be added to with a new mix, or it may be carved, planed or sawed for any fabrication desired.

Setting and Thermal Expansion

SETTING AND THERMAL EXPANSION

When a gypsum cement is mixed with water and the resulting fluid mixture changes to a solid, there are certain volume and temperature changes which start with the initial set. These changes consist of a setting expansion and a thermal expansion.

The thermal expansion recedes as the heat of crystallization leaves but the setting expansion is permanent.

The setting expansion varies with each type of gypsum cement, the consistency at which the material is mixed, and the temperature of the mixing water. Water at room temperature, or below, is recommended.

Upon making patterns and models, this expansion of the cement must be provided for, as it is this slight but positive expansion which enables gypsum cement to free itself from the surface upon which it sets, and is responsible for fine detail reproduction.

Setting expansions and other "controlled" properties for the various cements are listed under "Physical Data" on page 46.

Who Is Best Qualified to Use These Materials?

Skilled craftsmen with a background of pattern, foundry or die work can utilize all of their past experience to take advantage of the possibilities offered by this material.

Anyone applying the methods described in this manual will have success in gypsum cement pattern making in direct proportion to the skill and knowledge he acquires in following these directions.

Necessary Shop Equipment

Proper equipment is necessary to make gypsum cement patterns and models. It is comparatively inexpensive, the size and type of work contemplated determining the equipment needed.

WORK BENCHES

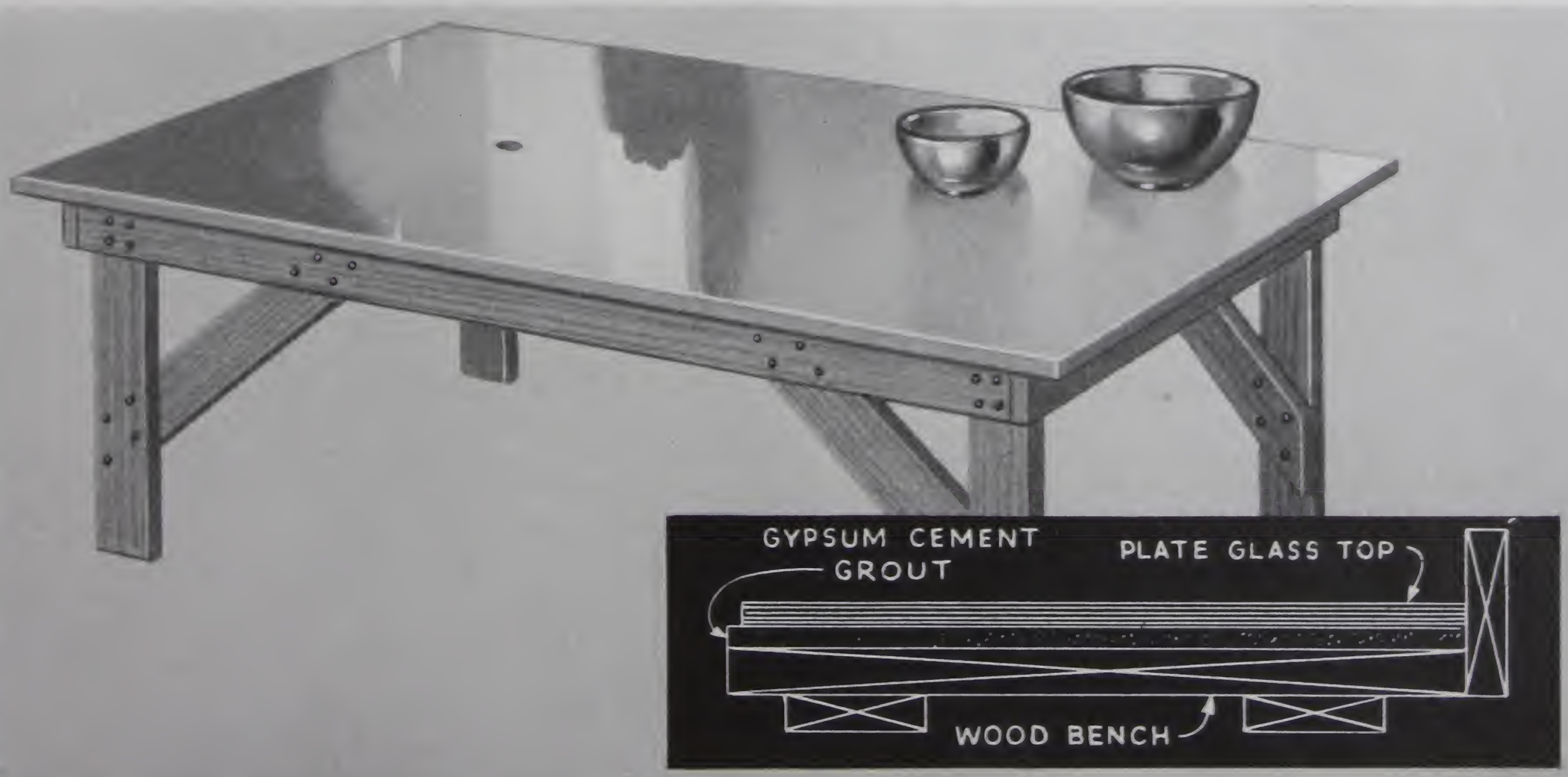
WORK BENCHES The size of the job being made governs the height of the bench. The main body of the work should be in as convenient a position as possible. The entire surface should be flat and can be either marble, slate, polished plate glass, or treated hardboard. Iron benches can be used, but the rust resulting from moisture must be removed constantly.

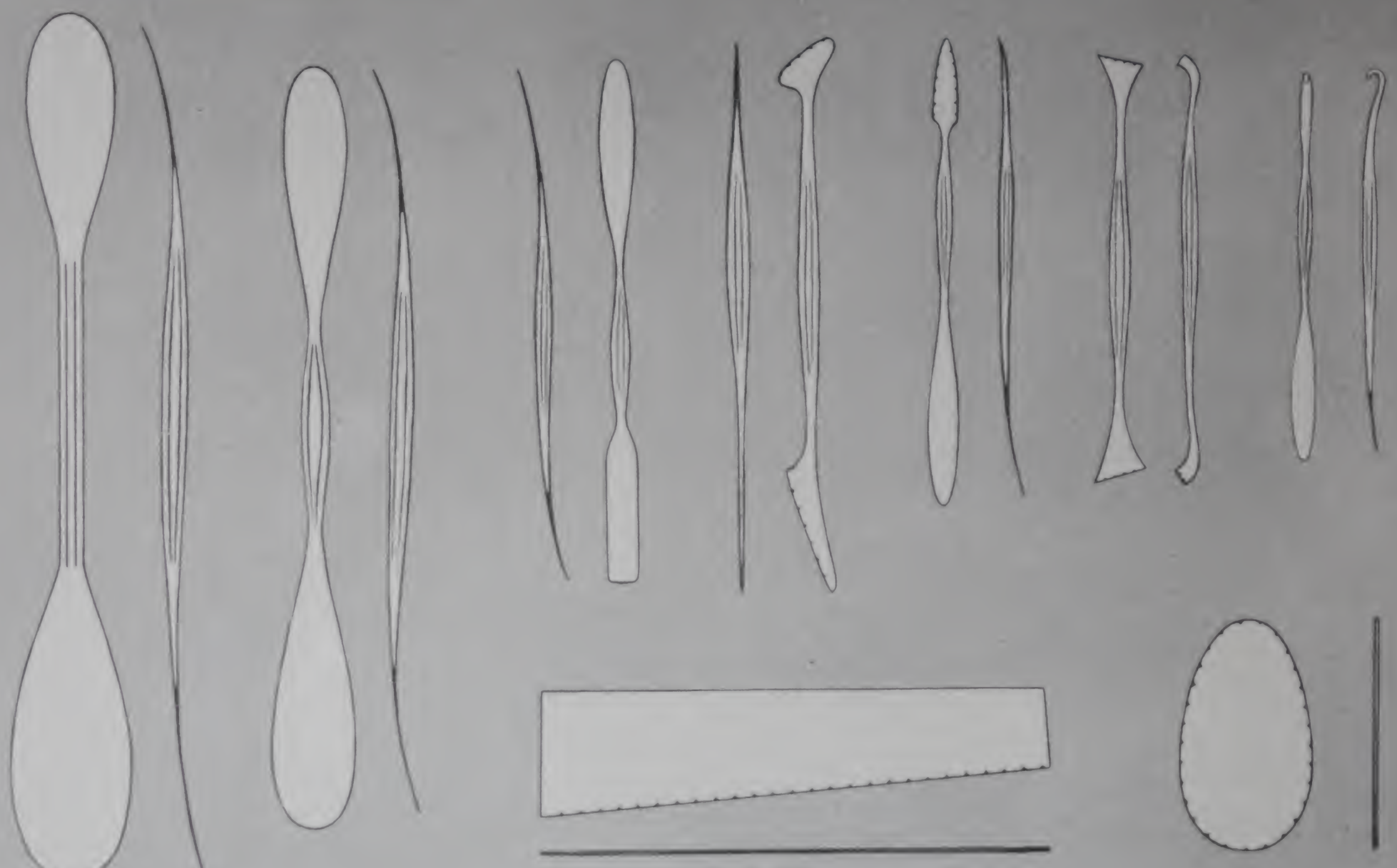
The benches must have straight edges. The better the work bench, the better and more accurate the work that can be produced.

MIXING BOWLS

MIXING BOWLS Mixing bowls should be semi-spherical in shape, made of spun or stamped brass or stainless steel. They should be flexible enough so they may be sprung, to remove set gypsum cement easily.

A typical work table is illustrated below. Lower right shows method of preparing bench tops.





TOOLS The tools used for this type of work are mostly special equipment. Diagrams for making the most important ones are shown in this manual. They are easy to make, and are essential to making a good job.

Scrapers are of various shapes and sizes.

FLAT SCRAPERS—with 1 edge smooth and 1 edge sawtoothed.

KIDNEY SCRAPERS—smooth edged and sawtoothed.

SPATULAS—of varying sizes.

HAND SAW—large-toothed and wide set to enable saw to clear itself.

BLOCK PLANES—size again depending on the work.

REGULAR CARVING TOOLS—as needed.

CUTTING AND FILING EQUIPMENT—for metal templates.

ANGLE PLATES and all other usual devices for pattern making.

WATER facilities nearby for frequent washing of hands.

Consistency of the Mix

The majority of all troubles encountered in working with gypsum cements is due to mixing the materials at an improper consistency. Each gypsum cement has its distinct water-absorption limit, known as its "normal consistency." This is the consistency at which it is normally used. However, at times it becomes necessary to vary this consistency either below or above normal so that the required bond and finish can be produced.

This is particularly true in overcoming the danger of water-soaking, because if the "set" gypsum cement becomes water-soaked, it will not form a bond with the second mix. Therefore, to compensate for this, the first mix is made below normal consistency, to allow for the added water it will absorb from the fresh mix. This procedure will be noted as you follow the examples given in this manual.

Hand Mixing

HAND MIXING

All mixing equipment should be clean—free from "set" cement and other foreign material. This is important, as "set" cement will accelerate the "set" of the new mix, thereby changing its entire period of plasticity.

Weigh the cement, and measure or weigh the water.

The cement should be sifted or strewn into the water *evenly*. Avoid dropping handfuls of the cement into the water at one time.

Allow to soak 2 minutes, undisturbed, then mix thoroughly. Stir from the bottom, forcing the material to the top. Care should be taken that no air is beaten into the mix during this process. Air will be forced out of the mix with proper mixing. Keep mixing until a smooth, even mass is produced.

Mechanical Mixing

MECHANICAL MIXING

When using a mechanical mixer, be sure the mixing bucket is of proper size and design. (See illustration on page 48 in this manual.)

Weigh the cement and measure the water accurately for each mix. Sift or strew the cement into the water slowly and evenly. Handfuls of the cement should not be dropped into the water.

Allow to soak from two to five minutes. Mix from two to five minutes. Experience will determine the correct length of soaking and mixing time. Use a clock to time the soaking and mixing operations to insure uniformity of mixes. Due to the speed of machine-mixing, there is danger of over-mixing unless this process is accurately timed.

Mechanical Mixer Specifications

MECHANICAL MIXER SPECIFICATIONS

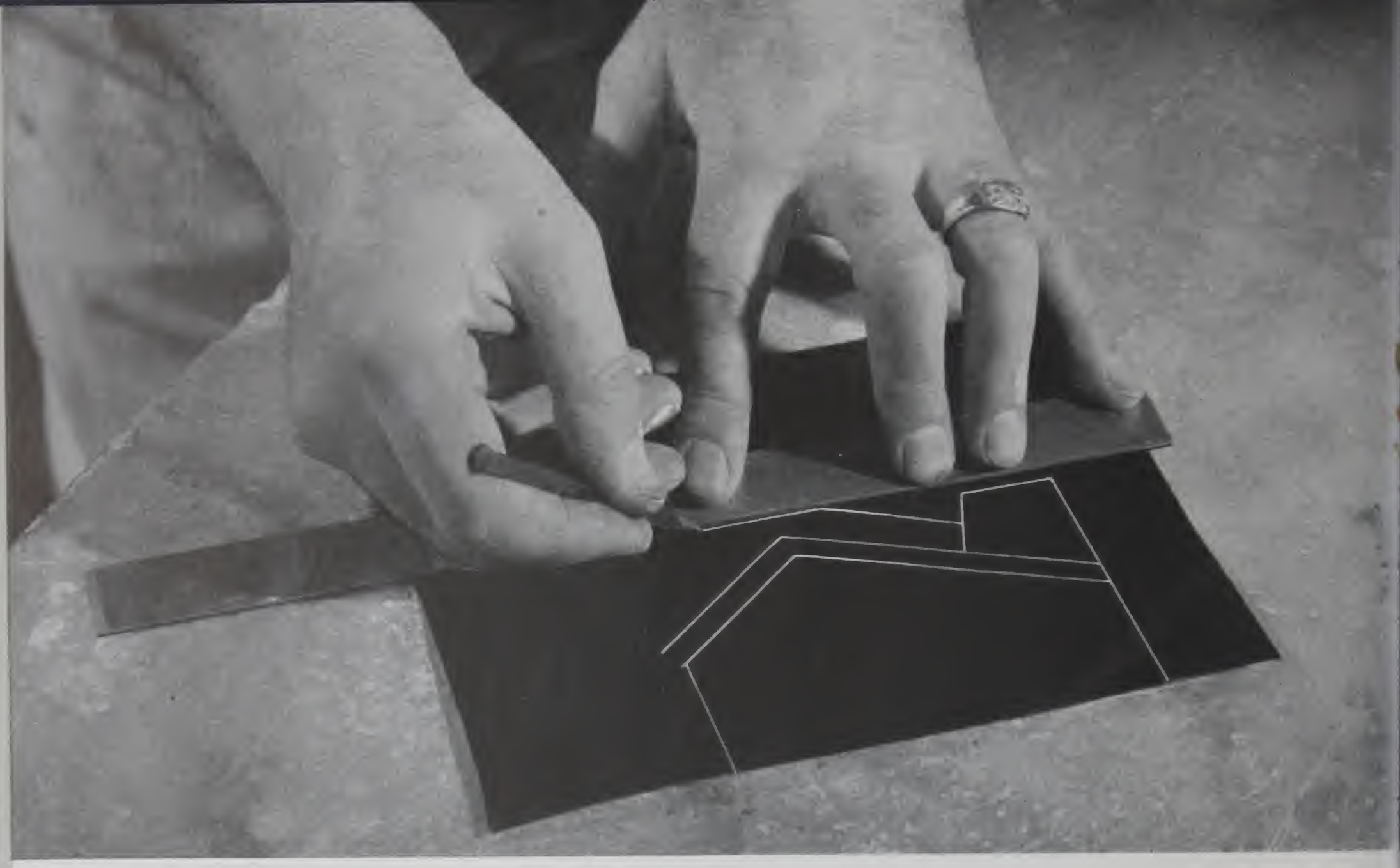
MOTOR For batches 10 to 50 pounds: ¼ or 1/3 h.p., 1760 r.p.m. direct drive.
For batches of 50 to 200 pounds: ½ h.p., 1760 r.p.m. direct drive.

MIXING SHAFT The mixing shaft should be set at an angle of 15° from the vertical and the propeller should clear the bottom of the container by one or two inches. While mixing, the shaft should be about half-way between the center of the container and its side. The propeller rotation should force the mix downward.

PROPELLER BLADE For batches of 10 to 50 pounds: 3-inch diameter, 3-blade, 25° pitch propeller. For batches of 50 to 200 pounds: 4-inch diameter, 3-blade, 25° pitch propeller.

NOTE: It is of extreme importance to keep all equipment clean, to avoid acceleration of the "set."

FIGURE 8



To make a template all contours and reference lines are accurately scribed with an awl on the metal to be used. The template is then cut and filed to the scribed lines. It is imperative to have a smooth and accurate template.

THE USE AND CONSTRUCTION OF A TEMPLATE

The Use and Construction of a Template

A template is a piece of metal which is cut to the shape indicated by the blueprint, and is then used as a tool to screed or form gypsum cement to the desired shape or contour.

The thickness of the stock needed for the template depends upon the type of gypsum cement to be used. Steel or any metal strong enough to scrape the "set" cement is necessary. The thickness—or gauge—of the metal is governed by the hardness of the cement. For the hardest types of cement, 16 gauge is practical; for the softest, twenty-seven gauge, half-hard brass is satisfactory.

After selecting the correct gauge template stock, the metal sheet is generally first prepared for scribing (or transferring of the design from the blueprint) by coating it with layout dye—a blue coloring matter which makes the scribed lines easier to follow. (The dye may be obtained from pattern-makers' supply houses.)

When a number of steps are required to complete a pattern, and the templates are not required for future references, one template sheet is used, and the successive changes scribed on the template are cut out as the work progresses.

However, if it is necessary to keep the templates for future references, a series of templates must be made, one for each successive step. Each of these successive templates must register with the preceding one.

When these points have been decided, the scribing is done with the aid of a scratch awl. All reference lines must be scribed on the template for guidance.

After all lines have been scribed, the template is cut, and filed to follow the contour of the design accurately. All scratches and imperfections in the finished template will be transferred onto the finished work. It is, therefore, imperative to have a smooth and accurate template. It is now ready to be attached to the sled.

The Sled

THE SLED

The function of the sled is to support, guide, and steady the template as it is pushed through the plastic mass, screeding it to shape.

In using the sled, the bench is greased so that the sled will slide easily. Care must be taken so that there is no grease under the moulding being made. The sled consists basically of a "slipper-board," and the board to which the template is nailed, or bradded.

This template board is cut out to a contour roughly similar to the contour of the template. Clearance is provided so that the wood does not project beyond the template, thereby ruining the shape being formed.

The sled construction is modified as required by the type of work involved. This can be noted in the illustrations in this manual.

Shellac

SHELLAC

Shellacking is necessary to seal the pores of the cement.

Best results are obtained when flake orange shellac is used. It should be "cut" and thinned with *alcohol* only! Use no cutting agent except pure denatured alcohol, as other cutting agents may cause difficulty in separation.

The shellac should be cut back thin enough so that the first coat applied is absorbed by the cement. If the surface remains glossy, the shellac is too thick. Several thin coats are better than one heavy coat. No sanding is necessary.

Burnt Shellac

BURNT SHELLAC

Evaporating of the alcohol in shellac does not make a glue. Burning is necessary to make it adhesive. It is used when two or more pieces of "set" gypsum cement are to be glued together. It is applied with the fingers or a brush.

To "burn" shellac, the cut shellac is poured into an open vessel to which fire can be applied. The size of the vessel depends on the amount of burned shellac wanted, but the cut shellac should be at least ½ inch deep in the vessel. It is then set afire, and stirred intermittently while burning. When bubbles cover about one-third of the surface, the fire is snuffed out.

A skin will form over this burned shellac after it cools, which acts as a protection. The shellac can be used indefinitely as long as it is moist beneath the skin. However, take care not to use the skin when applying the shellac.

When using burnt shellac, both surfaces to be glued must be primed with several coats of regular "cut" shellac. As soon as the primer is dry, the burnt shellac is applied.

Parting Compounds or Separators

Parting compounds or separating mediums are used to separate one layer of gypsum cement from the other. The various materials which can be used for this purpose are listed on page 44 in this manual.

Basic Methods Used for Making Master Patterns

There are five principal methods employed in making gypsum cement patterns. Each is suited to a particular type of pattern, so the product to be made should be studied to determine which of the five methods is required. It is not necessary to be proficient in all methods to make many simple patterns, but after one process is learned, skill will be developed with other methods. The five methods are:

1. **RUN WORK**—or screeding a straight mould.
2. **RUN WORK**—in such shapes as square, rectangular or oblique.
3. **TURNED WORK** on the bench.
4. **ROD or BOX TURNING.**
5. **BUILT-UP WORK.**

Run Work—Straight Mould

This method is used to produce patterns or pattern stock for models having parallel edges or to form a straight moulding. It is the easiest and simplest type of pattern to make with gypsum cement. There is no restriction on the contours that can be produced by this method. Let's take a simple type job and make it.

The drawing calls for a mould contoured on the face and back. Because this is a double-faced mould, a first—or prime run—must be made. This run serves as a follow-board—(or support)—for the pattern.

Cut the template to follow the contour of the back of the pattern. Make the sled and grease the bench. The cement is mixed a little below normal consistency for the first mix, then allowed to "cream" a bit before it is placed on the bench in front of the template. If some of the cement is allowed to lap over the end of the bench, it will act as an anchor to prevent the mould from "sweating"* loose before the work with the template is finished. Plasteline, or modeling clay pressed on the bench at intervals also gives the cement a grip and helps anchor it in place.

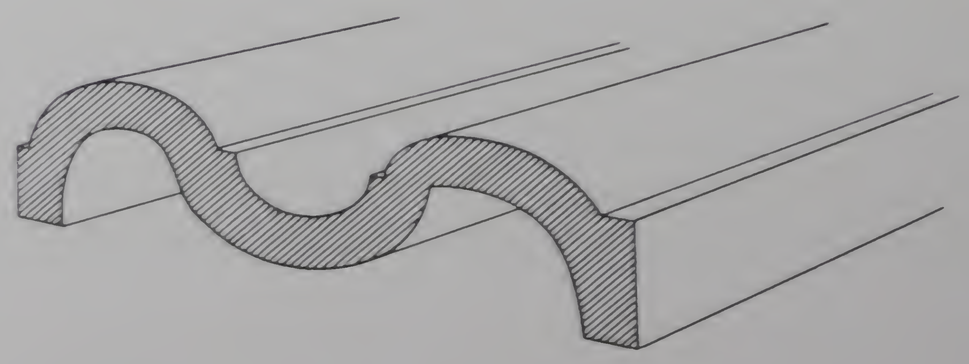


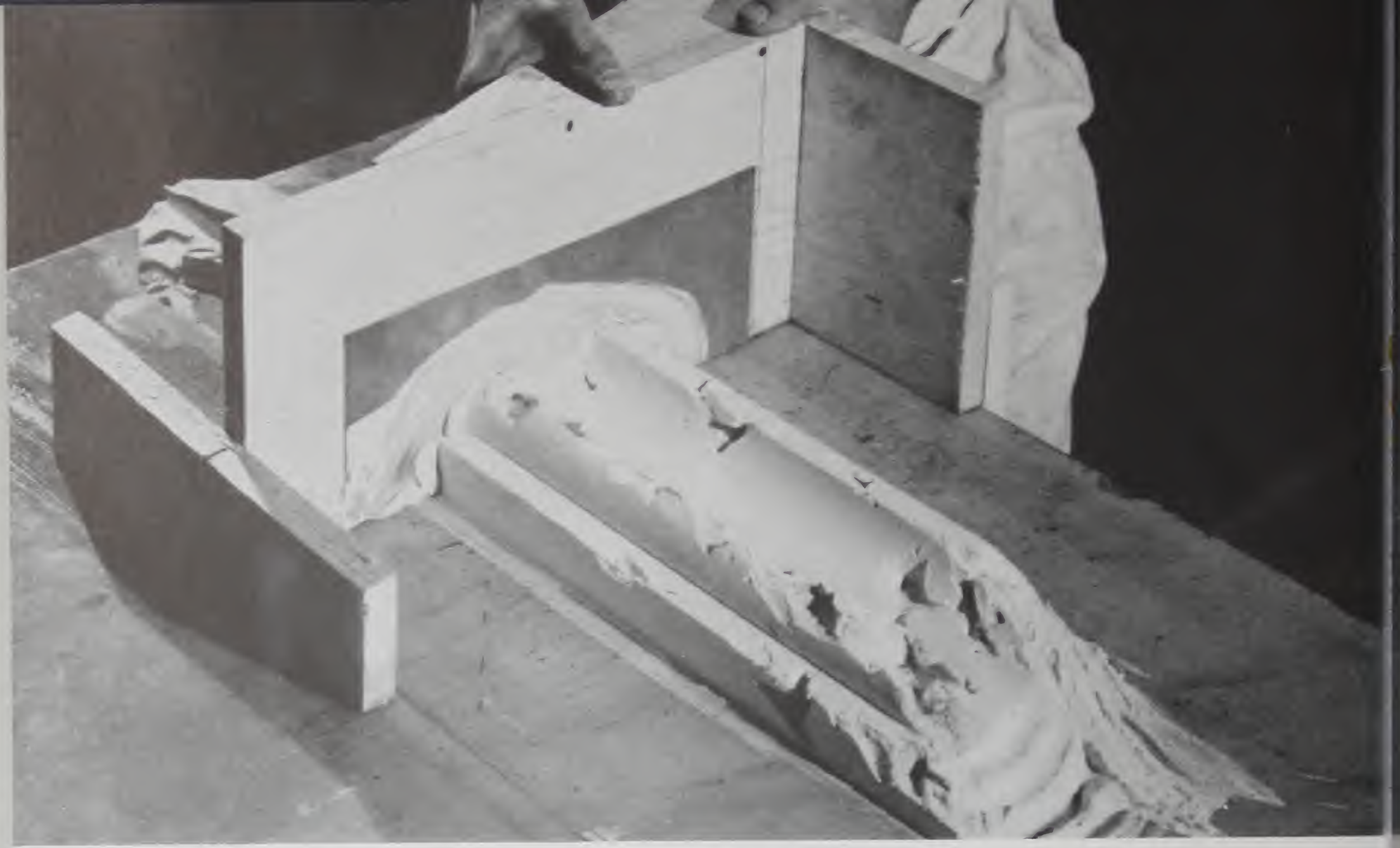
FIGURE 1

Run work is produced with a sled, constructed as shown. Note the guide board that slips along the straight edge of the bench. The outrigger board slides on the top of the bench and prevents "chatter." The template is bradded in place. Tools shown are brass bowl, saw edge scraper, flattened spoon for mixing, and three sizes of spatula.

FIGURE 2

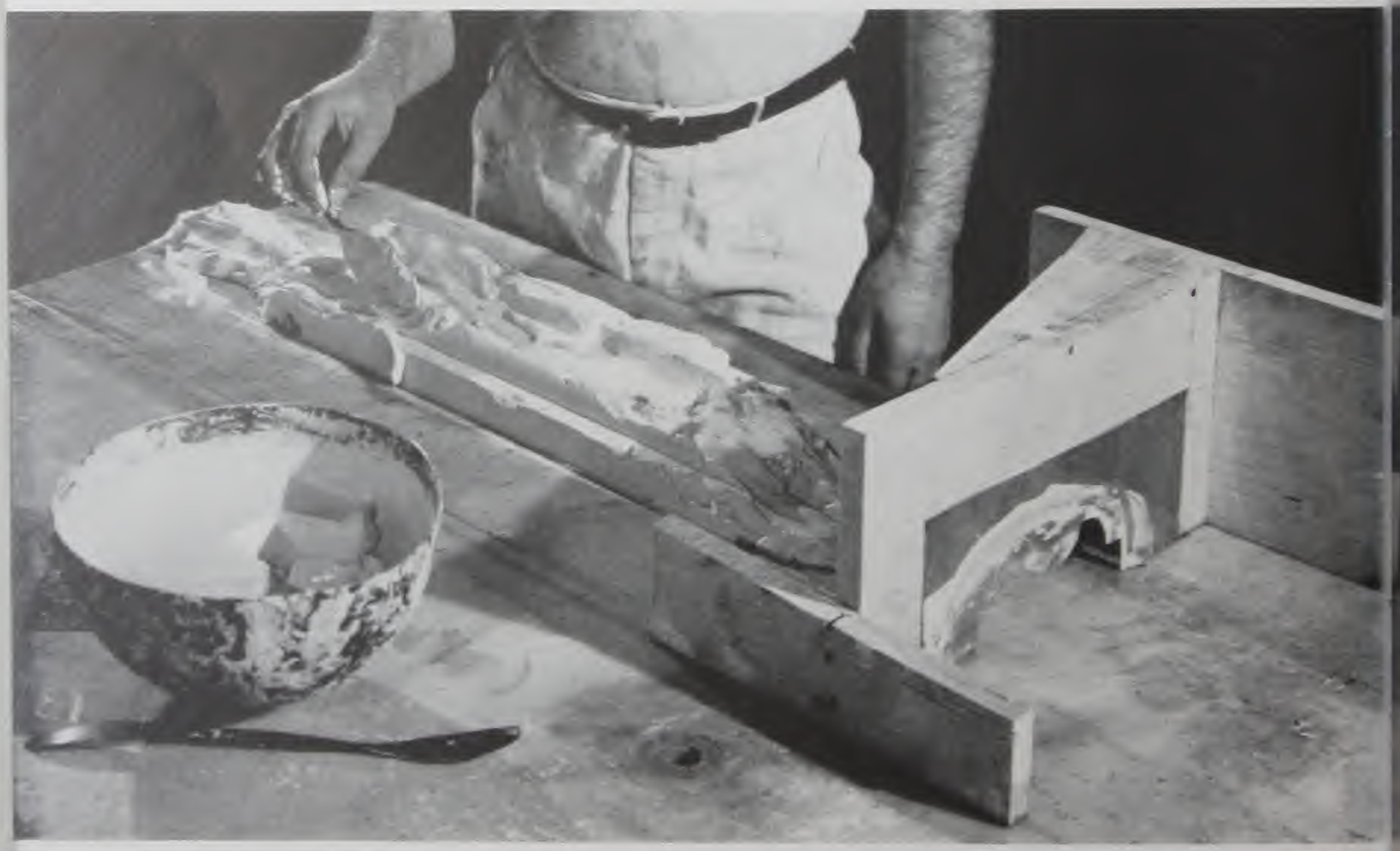
Gypsum cement mixed at below normal consistency is placed on the bench approximately to the outline of the template, which has been cut out to follow the contour of the back of the pattern. Some of the cement is allowed to lap over the edge of the bench to provide an anchor. As soon as the cement has been roughly placed in shape, the sled is pushed through the mass.

FIGURE 4



Here the cement has been screeded several times. The voids are built up before each screeding. The template should be pushed only in one direction, the metal cutting face striking the mass first.

FIGURE 5



The second mix of gypsum cement is applied into the voids left in the original run.

FIGURE 6

Next, push the template through the newly applied mix. Pressure is applied by holding the sled firmly against the bench with both hands. This is imperative to make the sled run true.

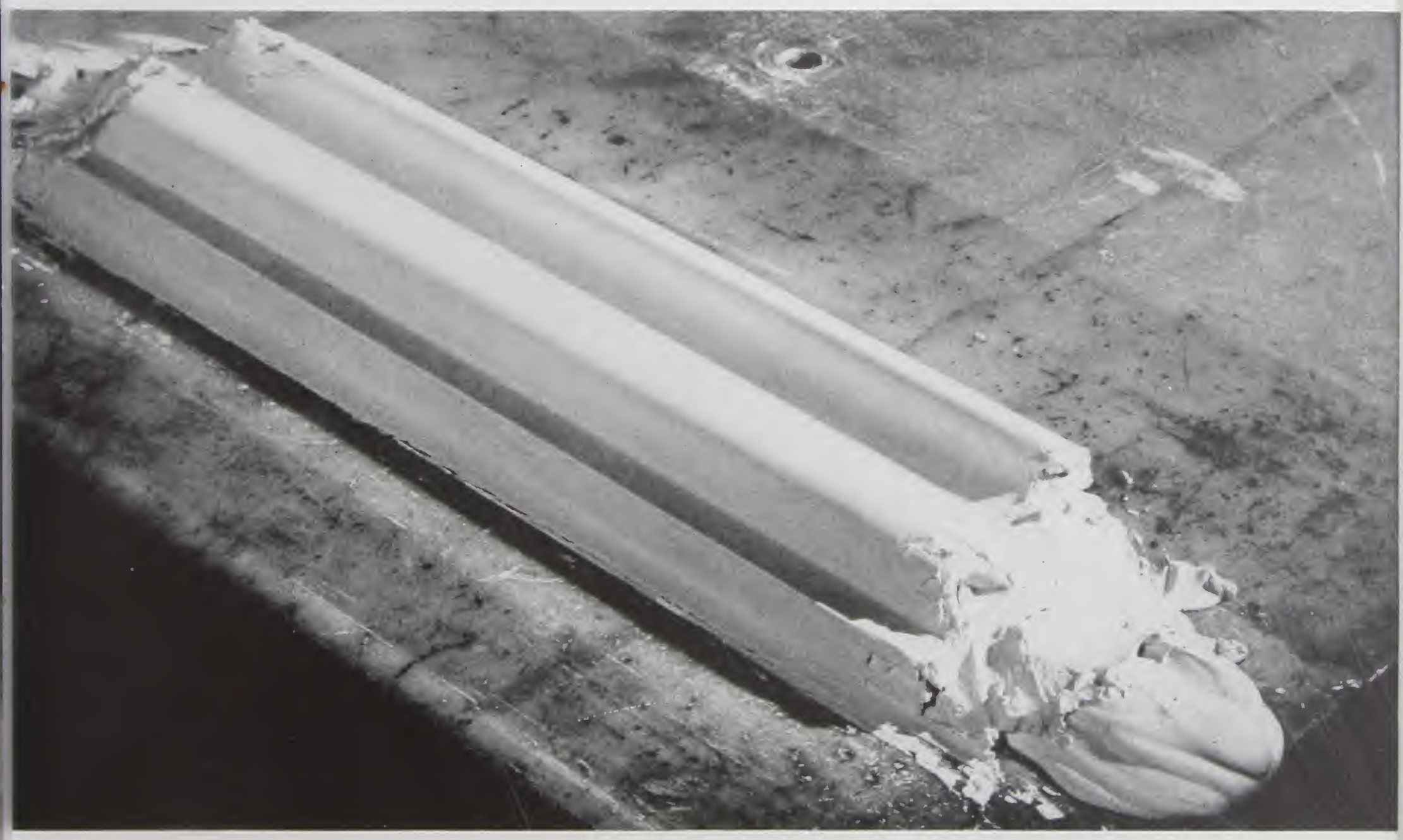
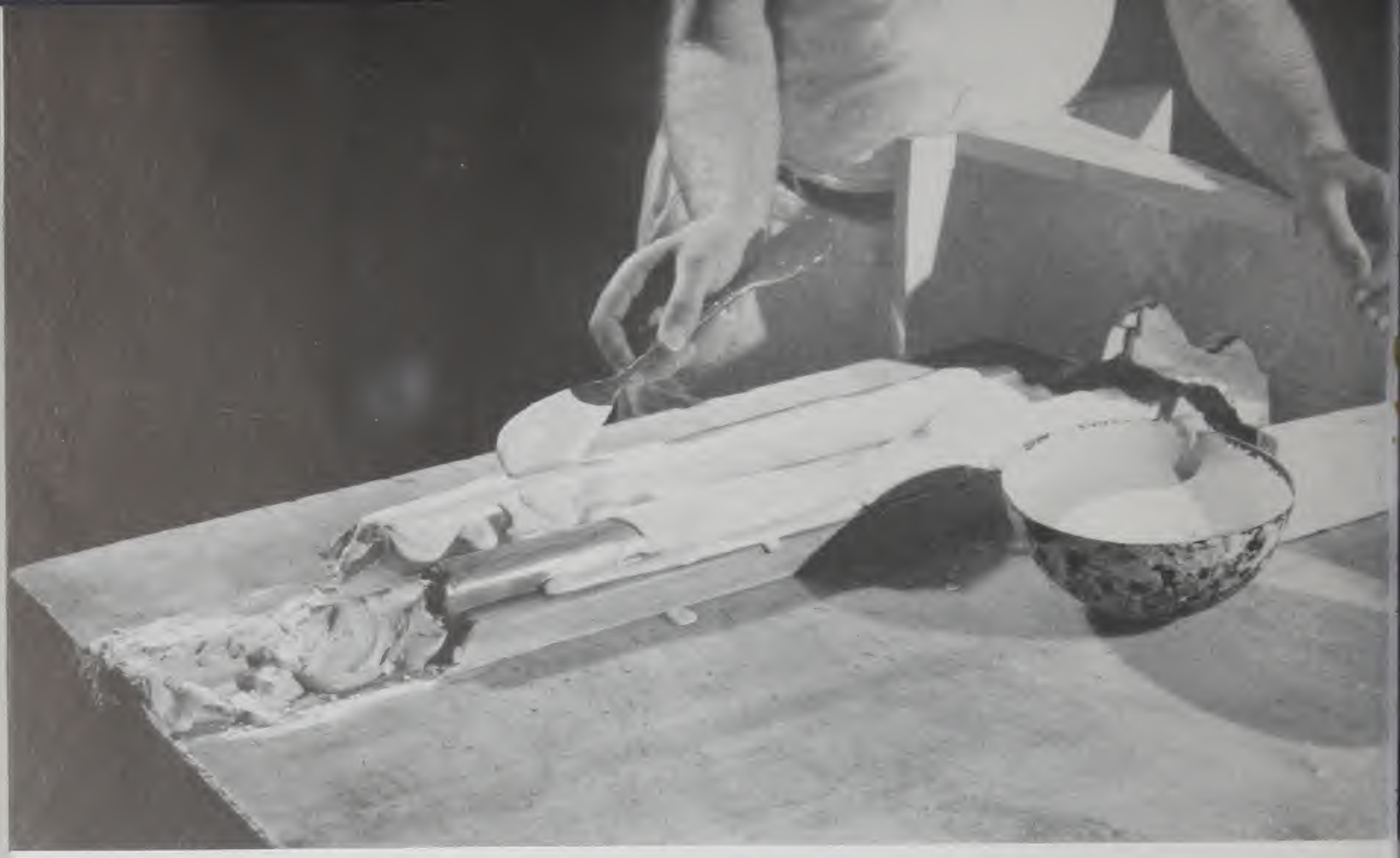


FIGURE 7

The prime run for follow-board is now completed, and ready for shellacking and application of the separator medium. (Note the way the cement overlaps the end of the bench for an "anchor.")

FIGURE 7



The template has now been changed to the face contour of the pattern. After the shellac dries and the parting compound has been applied to the follow-board, a new mix at normal consistency is spread over it. To avoid bubbles, the surface is covered while the cement is in its more fluid state.

FIGURE 8

The template is now pushed through this new mix to form the pattern. Note how the cement in this very plastic stage "rolls" as the template screeds it. Incidentally the function of the guide board of the sled clearly is demonstrated here.

FIGURE 9

The pattern is now completed and is sawed to length before removing it from the bench. The pattern lifts off easily.

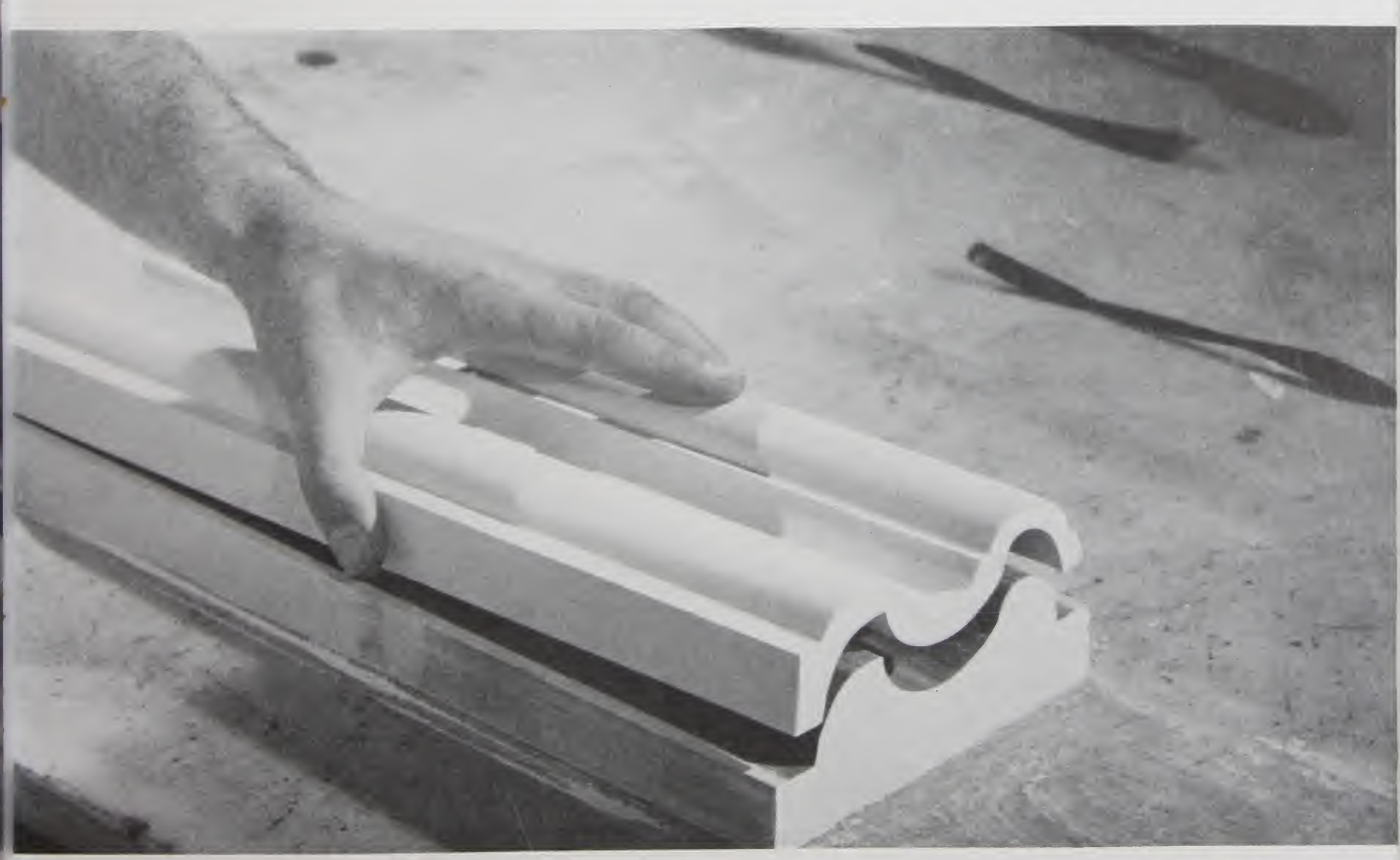


FIGURE 10

The completed pattern is separated from the follow board below. It is then shellacked and ready for use.

As the "creaming" action progresses, the cement becomes stiffer, and firmer, and therefore easier to control with a spatula.

Using the spatula, spread the cement in front of the template in a shape roughly resembling the outline of the template. Don't built up too great a mass for the template to remove at one time. It is better to build up gradually by adding more cement after each screeding.

The template is now pushed *firmly* through the plastic mass. It is always pushed in one direction *only*. When it has been pushed through the mass once, the sled is picked up, the template cleaned, and the waste cement discarded. Add more cement to the mould to fill in as much as possible, the remaining voids. Return the sled to its starting position and push through again. Repeat this operation as often as necessary.

The high spots in any profile are the most difficult to build up. Therefore the craftsman should pay particular attention to these. The low spots practically take care of themselves.

When this first mix has progressed so far through the period of plasticity that it will no longer make a good bond, stop working with it. *RETEMPERING GYPSUM CEMENT IS NOT* to be resorted to, as it will become chalky, and have no strength. The less the cement is handled during forming, the better. When a large mass of cement is used, it is not advisable to bring the cement directly up to the template with the first mix, because of expansion difficulties.

Now make a second mix and continue building up, filling the remaining voids and screeding, as before. If the mould is not completed with the second mix, a third or even a fourth mix may be used. However, these additional mixes should be made at NORMAL consistency. That is, they should be more fluid than the first mix, which was made BELOW normal consistency.

If when applying these subsequent mixes, the new material crumbles or tears, a greater amount of mix should be applied and screeded as quickly as possible. The cause of this crumbling or tearing is due to the absorption of water by the first mix which has "set" from the subsequent mixes used. However, care should be exercised not to apply so much new mix that the entire mould will become water-soaked.

When the follow-board—or support—has been completed, it is shellacked or otherwise sealed. Parting compound is then applied over the shellac. Meanwhile, the template is changed to the "face" contour by cutting and filing.

We are now ready to make the pattern. A new mix of gypsum cement is applied over the follow-board, and the screeding continues, using the same procedure as in making the follow-board. When this is finished, the pattern can be cut to length, carved, mitred, or further fabricated in any desired manner. It is then ready for final shellacking.

**When gypsum cement sets, it heats up to a greater or lesser degree, depending on the type of cement used. Water, due to condensation, settles between the plaster and the bench. If proper precautions are NOT taken, the mould will free itself from the bench before the screeding is finished.*

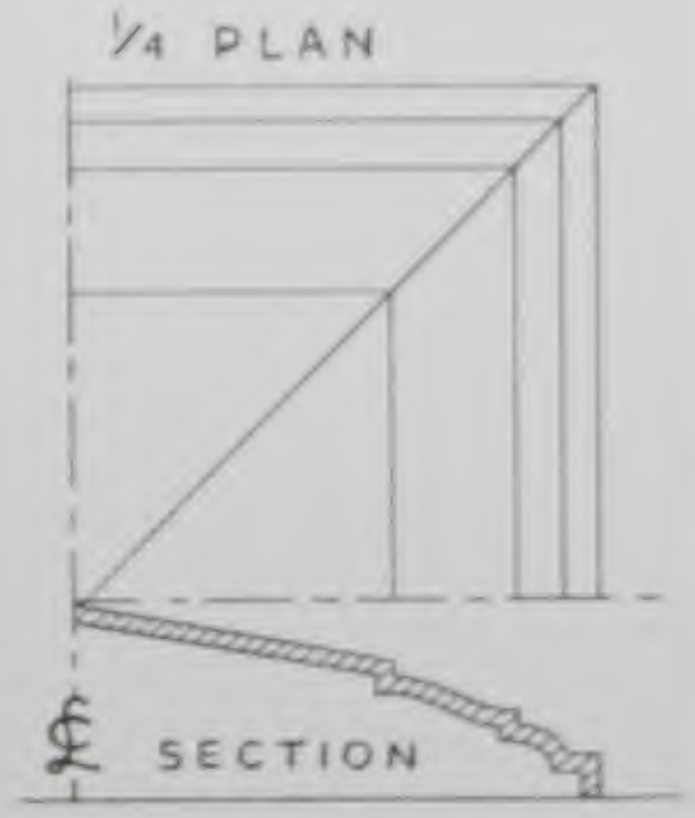
FIGURE 1

The template is cut to conform to the contour of one face. The template board must clear the entire pattern. The sled is made the same as for run work. The pivot stud on which the slab is rotated is covered to protect it from the cement. Since the drawing calls for a shell pattern, a follow-board is necessary. A number of brads are driven into the slab to serve as an anchor for the follow-board. The slab is then greased.

Square, Rectangular or Oblique Shapes

After proficiency is acquired in running a straight moulding, the knowledge can be used to produce square, hexagonal, rectangular, octagonal and multi-faced shapes. Joints or mitering will not be necessary.

The technique is the same as that used in running a straight moulding. The only difference is in the use of a slab which conforms to the basic shape of the pattern—(square, rectangular, hexagonal, etc.) only larger, so as to provide a surface for the sled to ride on. The slab is pivoted around a center stud attached to the bench. This pivot permits the job to be swung into a position convenient to the craftsman.



This drawing is for a square shell pattern. The accompanying illustrations describe the steps involved to produce this shape. The handling of the material in making jobs of this type is the same as for run work. Patterns made by this method need no mitering as the template produces the miter

FIGURE 2

To shape the follow-board, the template is passed along each side of the slab. Be sure to clean the template after screeding each face. The sled must be gripped firmly and uniform pressure applied to produce an accurate pattern.

FIGURE 3

When the follow-board is finished, it is shellacked and parting compound brushed on. The template is changed to the outside contour of the shell pattern. All surplus gypsum cement has been completely removed from template, sled and slab.

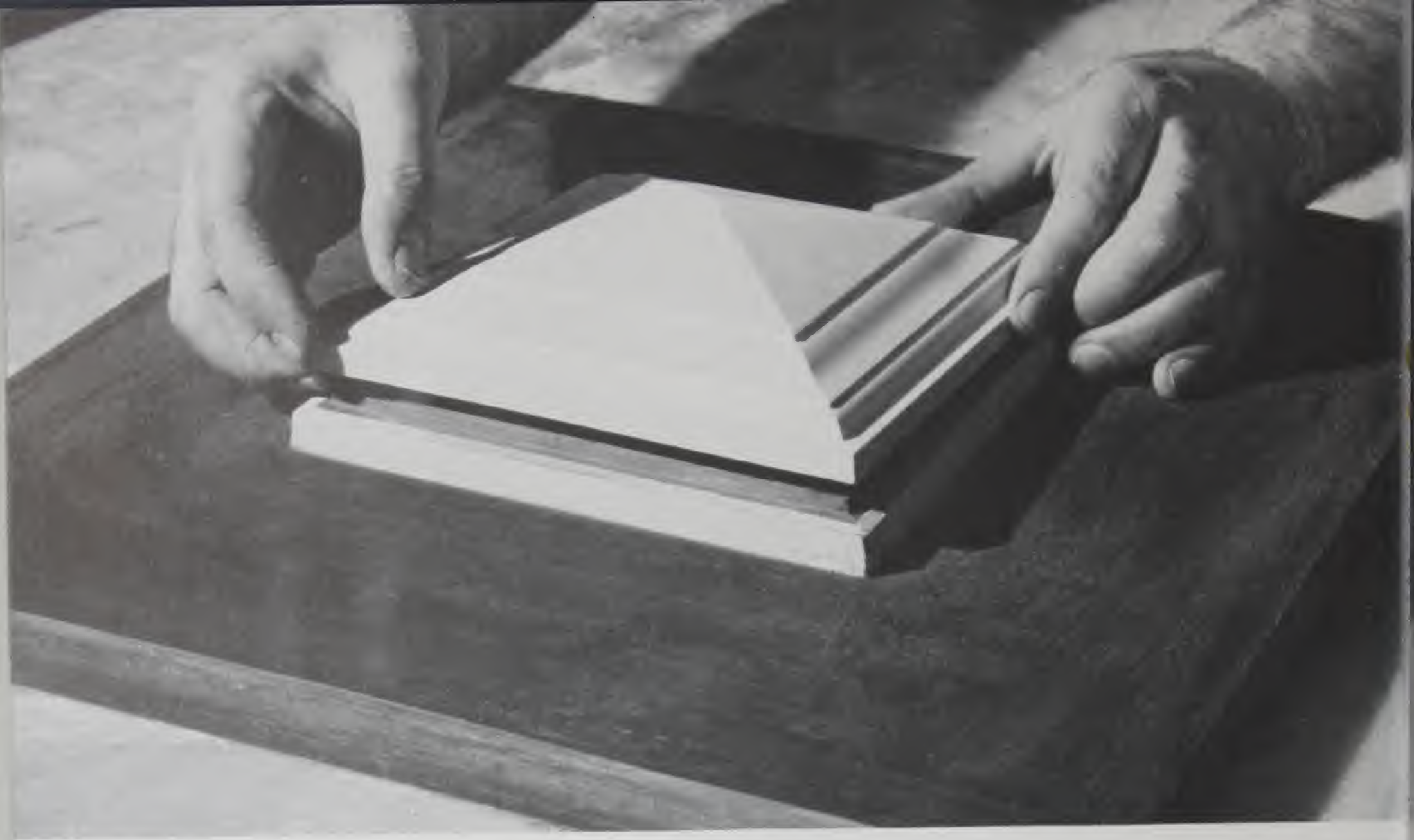
FIGURE 4

A new mix of cement, at Below Normal Consistency is placed over the follow-board, to start the shell pattern, and screeded.

FIGURE 5

A second mix at Normal Consistency is necessary to produce the hairline detail and smooth surfaces. Observe the plastic state of the cement.

FIGURE 6



When the final set has occurred, the shell pattern is removed from the follow-board. Good workmanship will produce a flawless pattern.

FIGURE 7

The interior of the pattern has all of the detail of the follow-board. If no bosses or appendages are to be added, the shell pattern is shellacked and is ready for use.

Circular Shapes (Turning)

Circular shapes, such as wheels, discs and housings, are made with a modified arrangement of the run work sled. The template is rotated around a center post to produce a symmetrical pattern.

For these circular shapes, the template is made with the center line scribed. A pivot plate is centered to this line and nailed or screwed in place on the template board.

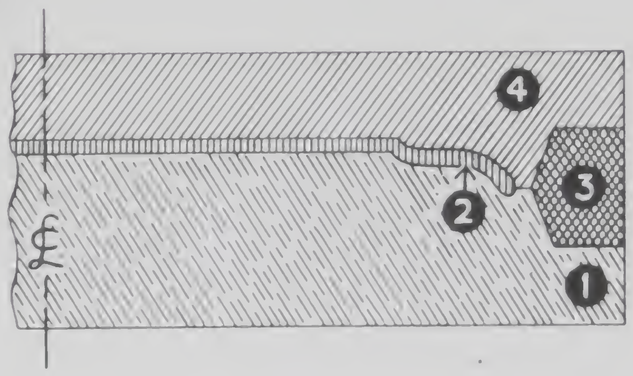
A center post is placed in a hole in the bench. This post should have a running thread, with a double nut for height adjustment. The pivot point at the top must be absolutely rigid and should be set higher than the top of the pattern to be made, so that the template will clear the pattern as it is rotated around the pivot point.

By application of this method of rotating the template around the center post, sweeps of any diameter, or segments, can be produced.

The mixing and handling of the gypsum cement in making a turning should follow the same procedure as explained for run work.

For thin sections, a follow-board must be made first, and the pattern built on it.

The accuracy of the finished work depends upon the accuracy of the equipment used. However, accuracies within 0.005 inch can be maintained by this method.



The drawing shows a typical example of circular shapes, which in this case is a die. This pattern is made in four parts, as shown.

For bench turning, a modified running sled is used which rotates around a pivot point. A pivot plate is fastened on the sled board at the center of the pattern to be made.

FIGURE 2

After the threads on the center post are covered to avoid getting gypsum cement into them, the mix at below Normal Consistency is placed on the slab to approximately the height and contour of the template.

FIGURE 3

The template is now rotated several times to screed and shape the mass roughly and to fill the voids as much as possible. Hold the sled firmly and rotate with an even pressure.

FIGURE 4

Clean the template of set material with the saw tooth scraper and apply a new mix at Normal Consistency to fill voids. A spatula of the correct size is used to apply the cement.

FIGURE 5

Details of the pattern are built up while rotating the sled by directing the surplus cement with the spatula. When the excess cement in front of the template loses its plasticity due to water absorption, it must be discarded. Add more cement until the details are completed.

FIGURE 6

When the shape is completed, excess material is removed from the finished pattern by rotating and lifting the sled simultaneously. No hand finishing is required as the template will pick up all excess cement.

FIGURE 7

Step 1 is completed by shellacking and applying the parting compound. The template is then changed and step 2 can be started.

FIGURE 8

Step 2 or the second part of this pattern is a thin disc, as will be noted by the thin gap between the top of step 1 and the template. The gypsum cement mix at below normal consistency is placed and screeded.

FIGURE 9

A small second mix at normal consistency is used to produce the fine finish. Excess material is removed from the work as the sled is lifted, while rotating, it is then shellacked and separating medium brushed on.

FIGURE 10

For step 3 or the spacer ring, the template has again been changed and a new mix at normal consistency has been prepared. The craftsman is taking full advantage of the controlled flow of the cement to place it in position for screeding. After the spacer ring is complete, it is shellacked and the separator brushed over the entire surface.

FIGURE 11

The final step is to change the template and make the last turning with a mix at normal consistency.

FIGURE 12

When the final turning is set, the sections are carefully pried apart and separated. If necessary, use a thin spatula, a wedge or compressed air to separate the parts. Fill in the holes in the center with cement, carving off the excess cement.

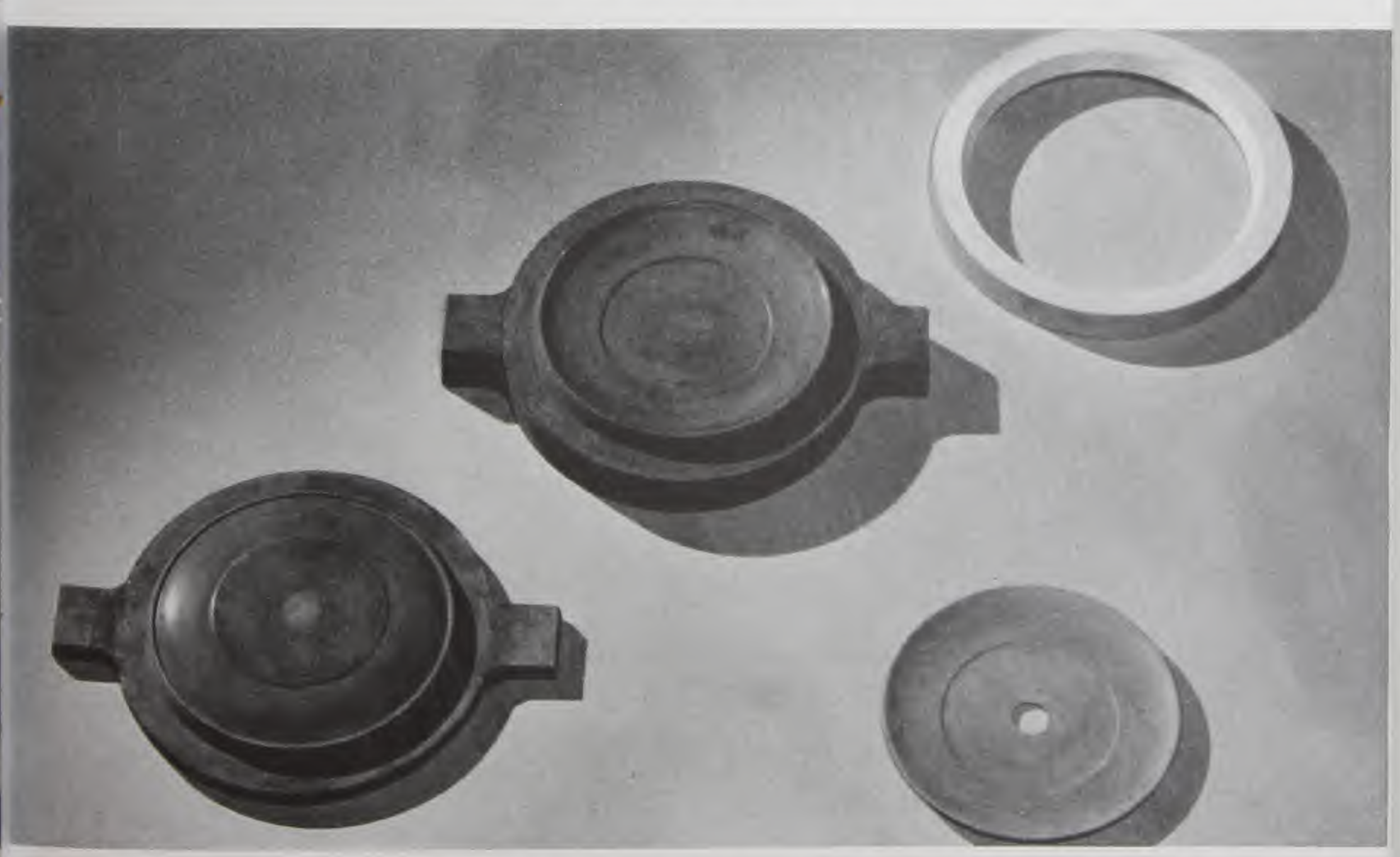
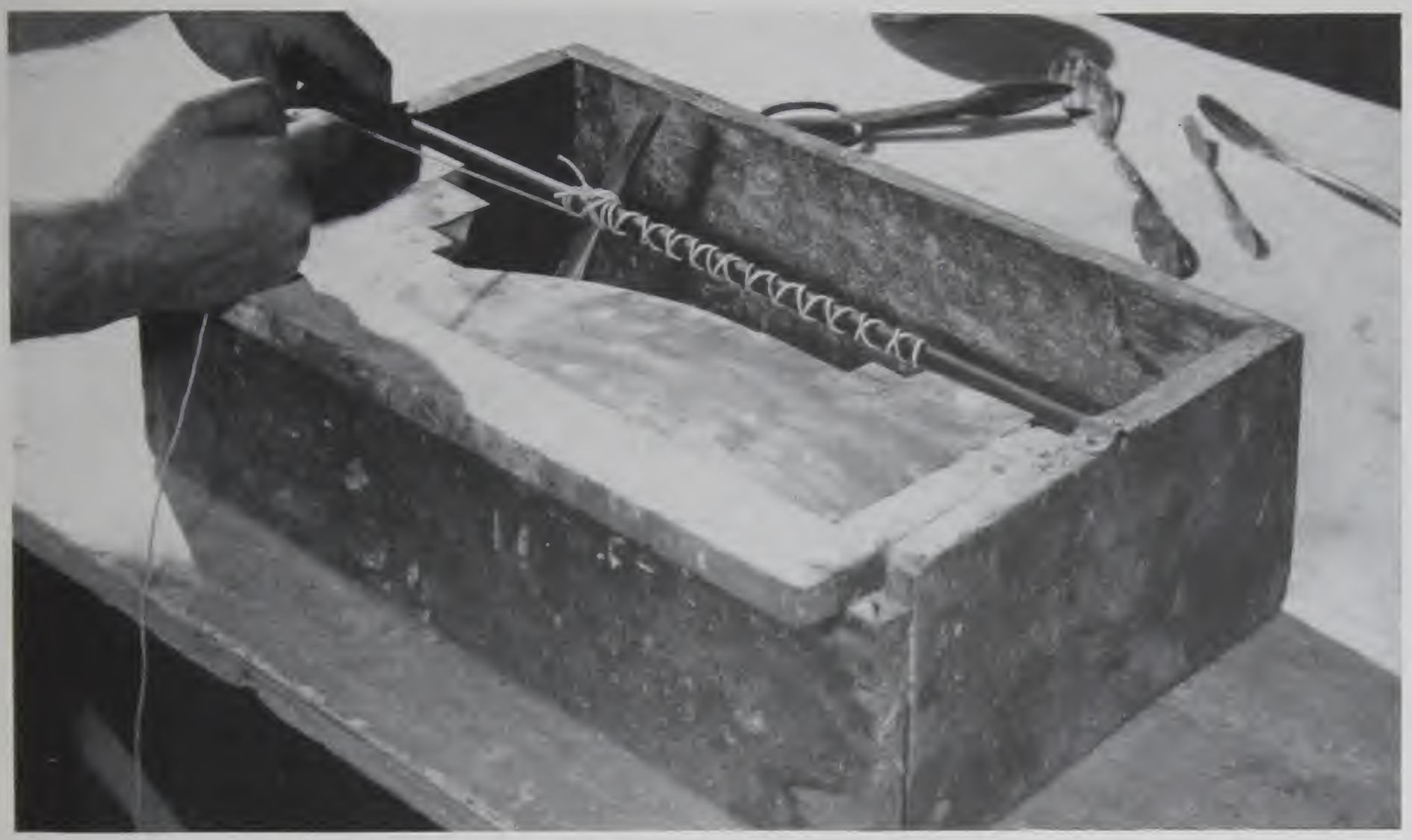


FIGURE 13

Ears are made by adding a fresh mix of cement in the desired thickness to the turning. They are then shaped by hand to conform to the drawing. The disc in the lower right hand corner can be used to check the accuracy of the pattern.

This is a typicol bench used for turning extremely accurate work in the pattern shop of a large aircraft plant. The craftsman is setting up his template which rotates on the horizontal rod. The two pivot rods in the background and their adjustment collets, are used for *segment* turning. The sleeve indicated by the arrow, holds the pivot rod when *full circles* are to be turned. All of these fittings are machined to insure extreme accuracy in the finished product.



The template for box turning is made the same way as for other work. However, a box with turning rod which rotates in journals is substituted for the sled. The template board is screwed securely in place to furring strips on the inside of the box, and is at center line height. The cord to provide a mechanical bond between the rod and the cement is in place and ready to be secured. A metal bar has been tied to the rod to help the cement at its maximun diameter.

Box or Rod-Turning Cylindrical or Kindred Shapes

These shapes require more experience in the handling of gypsum cement than the other methods, but it is the best way to make cylindrical or kindred shapes.

By this method, the cement is formed onto a rod which is rotated horizontally in journals in a box. As it is rotated, the excess cement is screeded by a stationary template attached to the box. It will be noticed that the *work* is rotated in this method, rather than the *template.*

The journals in the box must fit the size rod to be used. A handle, for turning, such as a lathe-dog, is clamped to the rod.

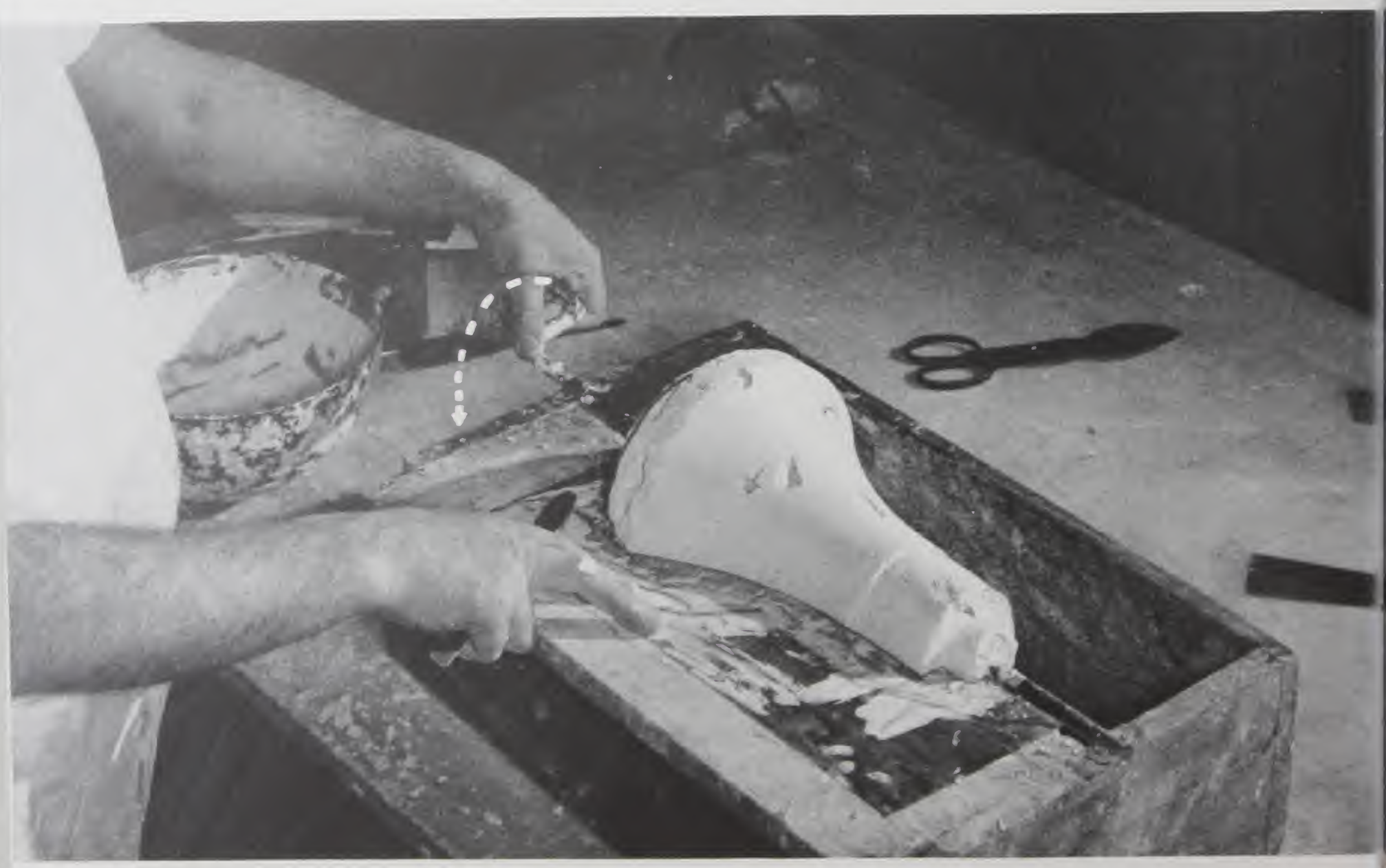
The template is made in the usual manner. However, the true center on the template must be cut away to allow for the radius of the rod. Therefore, an arbitrary line must be established on the template in order to locate it on the template board in its true position. The template board is fastened securely to the furring strips on the inside of the box which will support the template board at the center line height.

The pattern is built up on the rod in the following way: some twine is tied to the rod at the opening of the template. The rod is then rotated, and the twine guided in the manner of a screw thread, to the other end of the opening and back to the starting point, where it is securely fastened. This twine forms a bond between the rod and the cement.

FIGURE 2

The cement mix at below normal consistency is spread along the rod forming a body to which the subsequent mixes may be readily applied. None of this first mix touches the template.

FIGURE 3



A second mix at normal consistency is prepared and is built up to the template. The work is rotated slowly in the direction of the arrow only. The illustration shows the second mix has been used.

FIGURE 4

Another mix at normal consistency is applied to fill voids and give final finish to the pattern. When the cement loses its plasticity it must be removed from the template and discarded, and more mix added.

FIGURE 5

The finished pattern is removed from the box by lifting it out with the rod. The rod is removed from the pattern by twisting and pulling, and the pattern is ready to use.

A piece of metal can be tied crosswise to the rod at this time, if necessary, which will help support the cement as it is applied. If the rod is not to be used again, i. e., if it is to be left in the pattern, the piece of metal can be soldered to the rod.

A small batch of cement mixed at "below normal consistency" is now spread along the entire length of the pattern. The rod is rotated *slowly*, and as the cement "creams," more is added. Care should be taken not to apply *too* much of the mix at one time, as its own weight will cause it to sag away from the rod if applied in too great a quantity. Sagging will break the bond between the cement and the rod, consequently the pattern cannot be rotated, and it will be necessary to start over again. All that should be accomplished with the application of this first mix is to secure a firm foundation for the subsequent mixes.

All "glazed"* surfaces must be "roughened" before proceeding with new mixes.

As the pattern is rotated, the waste material that is screeded by the stationary template must be constantly removed and discarded. Only a clean template will produce satisfactory work.

All additional mixes required should be of "normal consistency" and the number of mixes needed depends upon how difficult are the contours to be built up. In applying these new mixes care should be taken that *large* masses of the cement do not come in contact with the template. A small clearance *must* be provided to allow for the "setting" expansion of this large mass. Failure to allow for this "setting" expansion will result in "chattering" as the pattern is rotated. This small clearance is then filled in with a finishing coat of a fresh mix spread over the entire pattern.

With good workmanship patterns of exce tional accuracy will be produced by this metho

*If gypsum cement is allowed to "set" undisturbed, it will form a glazed surface. This glazed surface must be "roughened" with any convenient tool before subsequent mixes are applied, or the following applications will not bond and are liable to peel off.

Box or Rod-Turning Principles Applied to Core Work

Where a core box must be produced, the method is altered somewhat from simple rod-turning procedure.

Template changes must be made as the work progresses. The template is first cut out and filed to conform to the shape of the core and its prints. The core is turned and when completed, it is shellacked.

A dam is now built up around the core at the parting line. This may be done by using either synthetic or natural clay, or by sawing boards to the contour of the core. Parting compound is applied to the exposed surface of core and dam.

A mix of gypsum cement at "normal consistency" is now applied over the entire area of core and dam, and built up roughly a little more than the thickness required. After the cement is set, the core box is removed from the core. The parting line is trued up, and if the core box is to be produced in metal, it can be carved to metal thickness and shellacked.

With the core box finished, the template is now ready to be cut to the contour of the pattern. After this is done, the core is "roughed up" a bit to provide a mechanical bond for the new mix. This new mix is screeded to the shape of the changed template and the finished pattern shellacked.

Any pattern made by this method will produce the metal thickness specified by the blueprints, if the template has been scribed, cut and filed accurately.

Built-Up Work

On designs where irregular shapes, or combinations of shapes are required, or where patterns are to be produced with the aid of lofting templates, BUILT-UP work is required.

By combining shapes produced by any or all of the other methods described in this manual, the types of patterns which can be made by BUILT-UP work are unlimited. To make a composite pattern, the different sections can be glued with burnt shellac if surfaces are present. If, however, blending is necessary to make the joint, free-hand work will be required.

FIGURE 1

For built up work, a fibre reinforced gypsum cement slab approximately ¼ inch thick may be used in place of metal reinforcement. The fibre is spread over the bench and the mix spread into it.

FIGURE 2

The fibred slab is sawed to size and will be bent to serve as a backing to span the gap and fit between the templates. These templates also have been made of gypsum cement.

FIGURE 3

The fibre slabs have been bent and tacked in place with gypsum cement. Fibre bats are then dipped into the cement mix and placed over the slabs to reinforce the pattern. The bats are applied almost to the template line. Space must be allowed between the bats and the finished template line for a finish coat of cement.

FIGURE 4

Care should be taken in handling these bats to keep them flat, so they can be spread evenly.

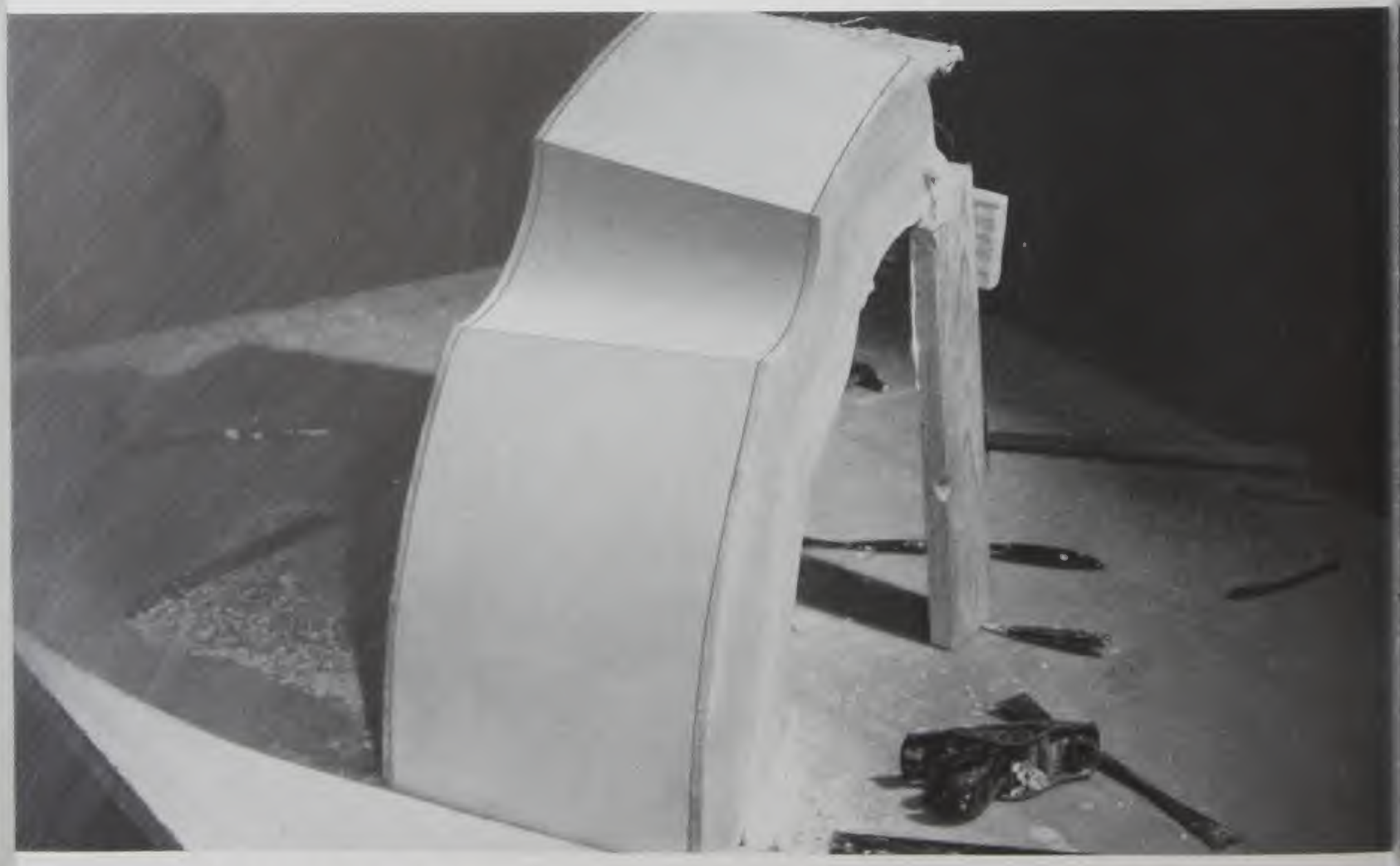
FIGURE 5

When the body is built up within approximately ¼ inch of the finished line, gypsum cement is spread over the surface with a spatula and scraped as smooth as possible before it sets.

FIGURE 6

Avoid wavy surfaces by scraping in various directions with the saw tooth edge of the scraper.

FIGURE 7



The final finish is produced by planing, carving and sandpapering.

FIGURE 8

To strengthen the pattern, place supporting strips of wood or metal on the inside and tie in place with fibre bats dipped in the mix. These illustrations show the principles of contouring and built-up work with the aid of lofting templates.

In BUILT-UP work, gypsum cement slabs are used similar to the way boards are used in wood work. Slabs can be cast by spreading the gypsum cement on the surface of the work bench. As it "creams," it is built up to the thickness desired. If both faces are to be parallel, the center should be built up a little higher, and some thickness blocks are placed at the edges. A piece of glass is then pressed down until it rests on the blocks; the excess cement will be squeezed out at the sides. These slabs can be made to any thickness and contour. They can also be reinforced with any convenient reinforcing material to give them added strength.

When "LOFTING TEMPLATES" are used as in aircraft or similar type work, they are set up in their specified positions. The gaps or spaces between the templates can be spanned by the use of reinforcing slabs or expanded metal. The slabs may crack in bending, but the cracks will bind when a new cement mix is added.

The cement is put on free-hand in the shape of the lofting templates. This free-hand shaping is done mostly while the cement is still in its plastic state. After it has set, it can be carved, scraped or additional cement can be applied.

One word of caution: Gypsum cement should never be carved unless it is moist. If it is dry, it will chip ahead of the carving tool, making it impossible to produce a smooth cut.

This large and extremely accurate lofted pattern is an example of the type of work possible to produce with gypsum cement. The contour was controlled by use of metal lofting-templates, which can be seen embedded in the pattern.

Reinforcements

When added strength is needed, REINFORCEMENTS are added to the gypsum cement.

The one most universally used and versatile reinforcement is uncarded, long-fibre hemp. The hemp is matted in bailing, so it must be picked apart to loosen the individual strands. Then a handful is made into a flat bat and dipped into the cement mix. This bat can then be added to the under coating of cement being screeded, thus becoming an integral part of the pattern. The number of bats needed depend on the size of the job.

Handfuls of the hemp can be dipped into the cement mix and formed into a rope to tie metal or wood reinforcements in place.

Thin flexible slabs can be made by spreading the hemp on the bench and applying a thin layer of gypsum cement over it, pressing it firmly into the fibre, while spreading. After it sets, it can easily be cut into convenient size slabs.

Uncarded hemp or sisal fibre can be obtained in large quantities from wholesale distributors. In smaller quantities, from local upholsterers' supply houses.

Other reinforcements are wire mesh—expanded metal—metal rods and flax fibre for delicate work. Wire can be used as a reinforcement, but it must be wrapped with dipped hemp or flax fibre, which will furnish a mechanical bond between the wire and the cement.

Metal rods and wood bar reinforcements, which are to be used as supports for the finished pattern when handling should always be tied onto the work with hemp fibre after the "setting expansion" has taken place, to avoid distortion.

Wood should never be *imbedded* in the cement as a reinforcement. The moisture in the cement will swell the wood. This swelling will distort the pattern.

Pouring Plaster Into a Mold

This method is widely used in making gypsum cement reproductions.

The mixture is poured into the cavity from one side. In this manner the air is driven ahead of the cement, and reduces the number of air bubbles. One of the characteristics of gypsum cement is its tendency to form pinholes or air pockets on its surface. To eliminate and break down as many of these bubbles as possible, the mold should be jarred or vibrated while pouring.

Another method often used successfully to avoid air pockets is to spread a layer of cement over the face of the mold and then tamp with a brush. When these air bubbles are broken down, the rest of the mold can then be filled. The brush bristles should be as stiff as badger hair and should be thoroughly rinsed immediately after use so the cement will not "set" at the base of the bristles.

Parting Compounds or Separating Mediums

These formulae for separating mediums have been used quite generally for many years, and are the most common parting compounds used on models and patterns.

Stearic Acid or Stearine and Kerosene—Formula: ¼ pound stearic acid shaved to flakes, 1 pint kerosene, 1 ounce Aerosol O. T. 100.

Mix the three ingredients and heat* to the boiling point to dissolve them. Stir well. Apply to the pattern with a soft brush, preferably a camel hair brush. If brush marks show when applied, thin with kerosene. The thinnest film can be spread if the solution is warm.

Aerosol is added to this formula to keep the stearic acid, an animal fat, and the kerosene, a mineral oil, in solution. This mixture is one of the most widely used of all the parting compounds. However, it should *not* be used repeatedly on wet Hydrocal A-11 or Hydrostone molds since it is not compatible with them.

Petroleum Jelly (Vaseline). Petroleum jelly may be used successfully if it is cut back with approximately 2 parts of kerosene to one of jelly. Blend the mixture by heating* and stir well.

Lard Oil. Lard oil may also be used successfully if the pattern or model and room are warm at time of application. If room or model is cool, the lard oil will become too heavy and will not spread thin enough. Kerosene may be used as a cutting agent.

Light Lubricating Oil. Light lubricating oil may be used if applied sparingly. Excess oil may cause separator runs and produce a soft surface on the gypsum cement model.

Carnauba or Bayberry Wax. Carnauba or Bayberry wax paste is made of equal parts (by weight) of Carnauba or Bayberry wax and gasoline blended by heating.* The solution may be applied warm to either a dry or moist gypsum cement pattern and then allowed to dry. After the gasoline has evaporated, polish the wax with a cloth. This polished wax acts as a sealer, as well as a parting compound.

Soap. Potters or Neutral Potash Soap (English Soft Soap). After producing a thick lather with a sponge, spread over the entire mold or pattern area. Remove all excess soap with clean sponge in order to preserve pattern metal.

Spirits of Camphor. When fine detail work is being done, such as the reproduction of jewelry, spirits of camphor is the most successful separator.

**Note: This medium is inflammable when subjected to too much heat and proper precautions should be taken in its preparation.*

Working Qualities of U·S·Gypsum Cements Used for Pattern and Model Making

The word "Hydrocal" identifies a basic type of Super Strength Gypsum Cement manufactured by the U. S. Gypsum Company, under a patented process. Hydrocal Cements possess 2-4 times the strength and hardness of normal types of moulding and pottery plasters. Quality and uniformity of Hydrocal Cements are closely controlled to assure consistent performance. The following describe the physical and working characteristics of the various Hydrocal products for pattern and model making.

PATTERN SHOP HYDROCAL (Hydrocal Base) For pattern and model making where a moderately low "setting expansion," plastic, free forming material is desired and dimensional accuracy is necessary. A low expansion material which works well under the template. Has a gradual "set," with long period of plasticity. Does not get too hard and can be carved or otherwise worked freely. A general purpose gypsum cement.

HYDROCAL A-11 (Hydrocal Base). A high strength gypsum cement, having a low "setting expansion." Adaptable to production of hard, strong, tough models of uniform and stable dimensional accuracy. Employed for production of master models, Keller duplicating models, etc. Has normal gypsum cement setting time, rate of stiffening being very rapid after setting action begins. Recommended for slurry, casting technique.

HYDROCAL B-11 (Hydrocal Base). Similar to A-11 in setting expansion and dimensional accuracy with slightly less strength. It has greater plasticity and more gradual setting action. Is specifically designed for use in production of built-up models, or template-formed models. Does not carve readily.

HYDROSTONE (Hydrocal Base). Hardest and strongest gypsum cement made. Cannot be worked under template. Used for patterns where extremely hard surface is required. Also used for making Cope and Drag or Match Plate Equipment for the foundry and in production of best quality art castings, statuary, etc. Cannot be cast satisfactorily in glue moulds, but work well in plaster, rubber, Korogel, etc. Expansion about four times as great as Hydrocal A-11.

MOULDING HYDROCAL. A white, even setting Hydrocal base material. Expansion controlled, set stabilized. Working qualities similar to White Hydrocal, but better dimensional accuracy. Designed for use where alkalinity cannot be tolerated. Can be handled in glue moulds.

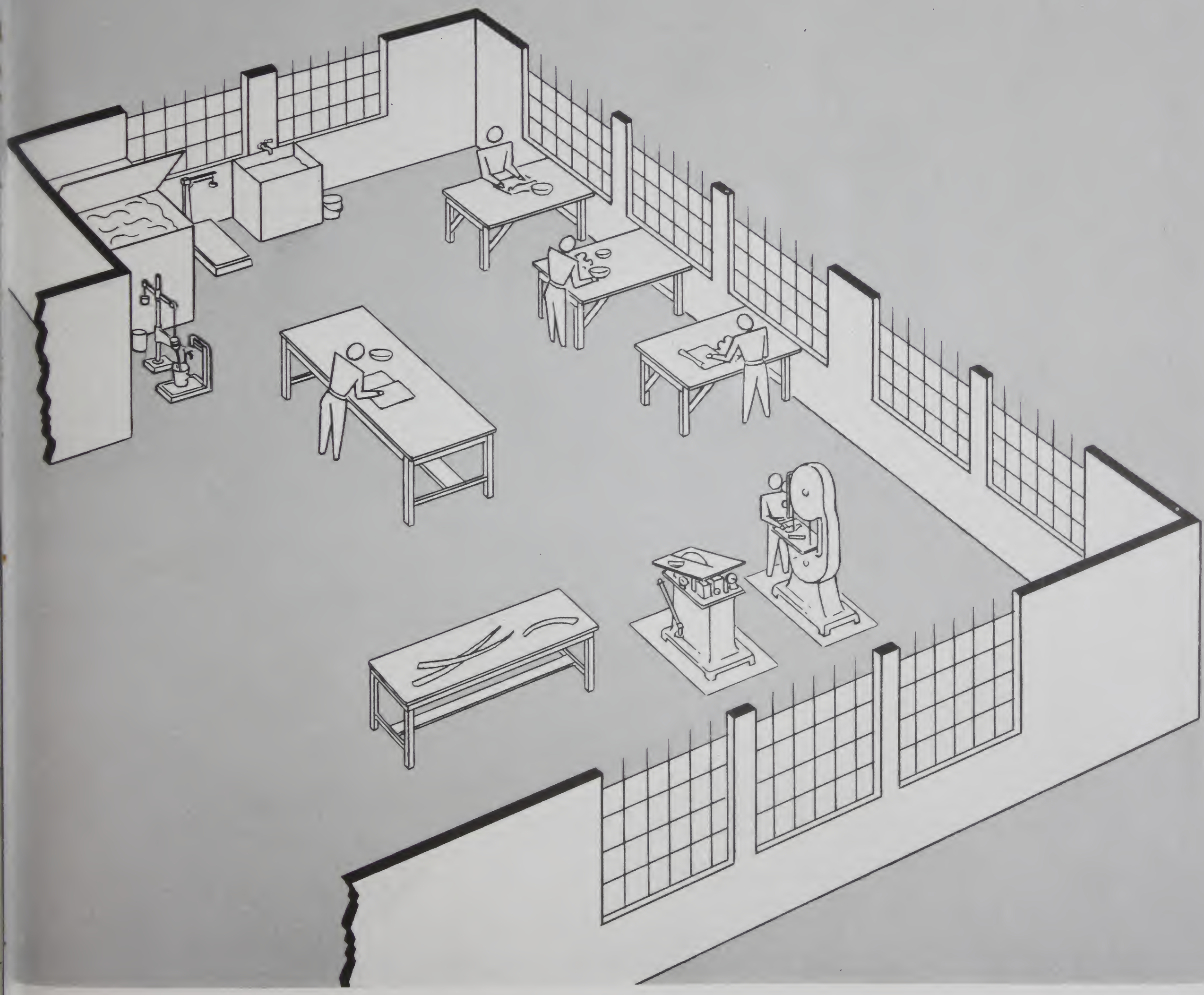
INDUSTRIAL WHITE HYDROCAL. A pure white Hydrocal having a gradual set and long period of plasticity. When run under a template, it is a little on the "short" side and has a tendency to tear. Has a high early strength—can be carved, added to, etc. High dry strength. Setting expansion 4-5 times higher than A-11 and about 25 percent higher than normal moulding plaster.

INDUSTRIAL WHITE MOULDING. This is the gypsum cement commonly known as "moulding plaster" or Plaster of Paris. Has a high degree of plasticity. Lower tensile and compressive strength than Hydrocal base cements. A good utility cement when expansion control, surface hardness and strength are not paramount.

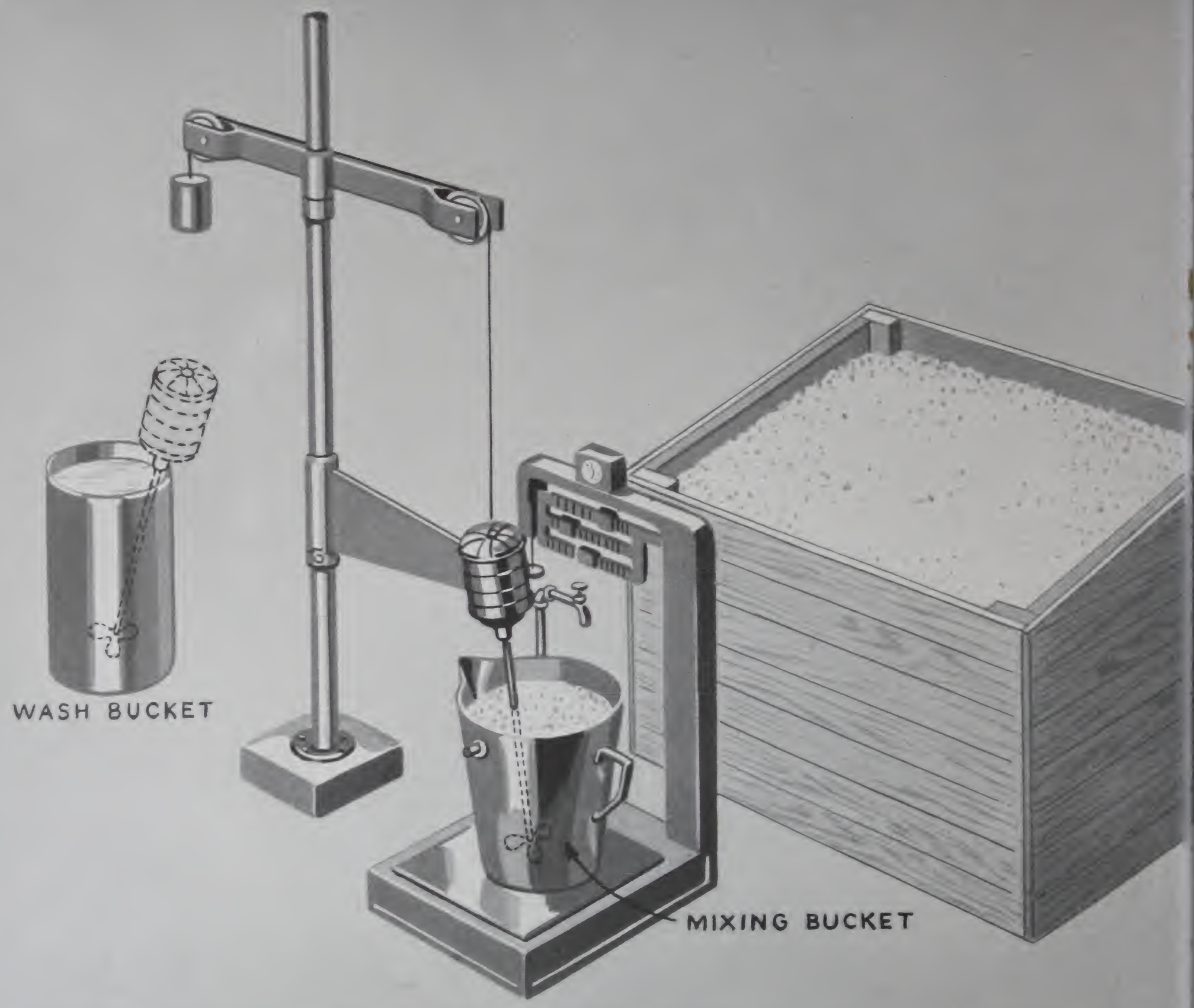
HIGH EXPANSION HYDROCAL. A special high expansion cement, designed for use in preparation of patterns to be reproduced in Kirksite, or similar die alloy. High expansion of the cement during "set" compensates for metal shrinkage after casting, permitting patterns to be made at same dimensions as required for finished casting.

	Industrial White Hydrocal	Moulding Hydrocal	A-11 Hydrocal	B-11 Hydrocal	Hydrostone	Industrial White Moulding	Pattern Shop Hydrocal	High Expansion Hydrocal	
Normal consistency	38-42	40-42	40-42	44-48	32 Max.	60-63	54-56	Consistency	
								35CC	40CC
Setting time Initial Gilmore Final Gilmore	20′ -30′ 30′ -40′	17′ -20′	16′ -22′ 20′ -26′	18′ -23′ 28′ -33′	17′ -20′ 22′ -25′	25′ -35′ 40′ -50′	25′ -30′ 35′ -45′	23 37	15 24
Setting Expansion Maximum Average	0.300 0.230	0.150 0.125	0.05 0.04	0.05 0.04	0.200 0.160	0.200 0.190	0.130 0.125	1.7%	1.5%
Compressive Strength (lb. per sq. inch) Minimum Wet Minimum Dry	2700 5500	2300 4500	2200 4500	2000 4000	4000 11000	1000 2000	1400 2800	1200 2900	900 2500
Tensile Strength (lb. per sq. inch) Minimum Wet	375	350	350	300	375	225	250		
Surface Hardness* Monotron Test	90	90	75	70	130	32	45		
Alkalinity	Neutral	Neutral	Alkaline	Alkaline	Alkaline	Neutral	Neutral		
Slurry pH	6-7	6-7	10-11	10-11	10-11	6-7	6-7		

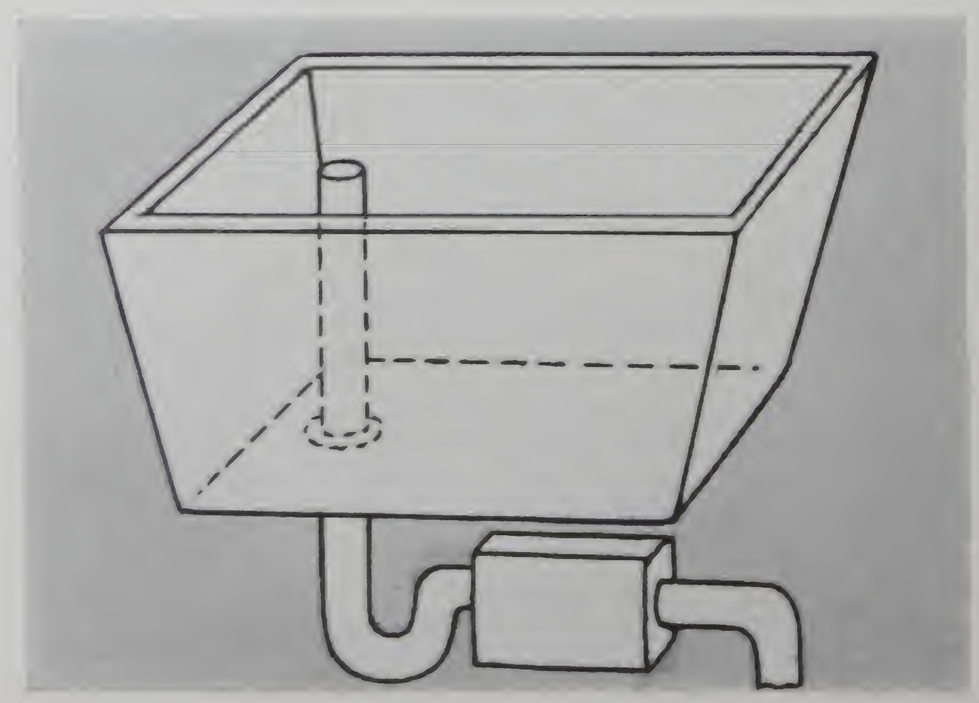
*Kg. load/0.01" penetration with 10 m.m. diameter steel ball.



Suggested Shop Layout.



Suggested arrangement of Mechanical Mixer.



Slop Sink with settling basin arrangement.

Industrial Gypsum and Lime Products

Industrial Gypsum Plasters and Fillers
Industrial Lime and Limestone
Hydrocals* (high compressive strength gypsum cements for Industrial uses)

Expanded Metals

Reinforcing Mesh (Expanded Metal)
Econo Mesh (Expanded metal for industrial uses)
Shelf X* (flat surfaced expanded metal)
Expanded Metal Grating
Railroad Carwalks

Roof and Floor Construction Systems

U·S·G Gypsum Plank (Metal Bound precast)
2½" T & G Precast Gypsum Tile
Short Span Gypsum Roof Tile (precast)
Sheetrock Pyrofill* (field poured)
Weatherwood Pyrofill* (field poured)
Steel Deck
Sheetrock* Roof Units

Other U·S·G Industrial Products

Durun* (wood fibre base plastic sheet)
Acoustone* (mineral acoustical tile)
Auditone* (wood fibre acoustical tile)
Industrial Insulation Board
K-Fae* (thermal insulating block)

*Trademarks Reg. U. S. Pat. Off.

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This famous trademark identifies products of the United States Gypsum Company—where for 40 years research has developed better, safer industrial materials.

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